Dolmatz and Wong

PHYSICAL SCIENCE

IDEAS AND INVESTIGATIONS IN SCIENCE

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IDEAS AND INVESTIGATIONS IN SCIENCE

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Idea 2: Matter
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IDEAS AND INVESTIGATIONS IN SCIENCE-PHYSICAL SCIENCE

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Preface

Welcome to IIS! Here is a course where you spend your time doing instead of sitting. No one is going to tell you all about science. Instead, you will have the fun of finding out for yourself.

The key to IIS is what you do in the laboratory. When you want to know what things are made of, find out in the laboratory. When it's something about how living things behave, you can get the word on that in the laboratory. In fact, in this class, you will find that the class is the laboratory.

Maybe your question is "What is atomic energy all about?" or "How come some people are taller than others?" Do you want to know why an Eskimo and a Hawaiian have the same body temperature, or how a TV picture is made out of tiny dots of light? Tune in on this course — it's made for you!

You are beginning to see the picture. IIS is not learning about science — it's really exploring your world. You will be doing what a scientist does, asking questions, guessing answers, and testing your ideas in the laboratory.

One thing about the lab work. In addition to discovering new facts, like what happens when two chemicals are mixed together, you'll be finding out what the facts mean. You'll discover a concept, a small idea about how something in nature works. Then you can look back over a set of these concepts and see some pattern to them. This gives you a big idea about how things work. This is just what scientists do, too: they build big ideas out of small ones.

So what is it with all this science jazz? Everyone is talking science, but what is it to you? Look around you. We have a surplus of problems. Too many people to feed. Too much pollution. Coast to coast traffic jams. You name it and someone is sweating it, but who is supposed to come up with the answers?

Most people are looking to science for answers, or at least a clue on how to solve the problems. If you want a piece of the action, then you have to know what science is all about. Here is where IIS comes in.

You will find out about the population explosion and pollution. You will also get into jobs and automation, drugs, smoking, and natural resources. You will find out that science is right here and now, not what someone else was doing 2 zillion years ago.

When the coach wants you to learn to play basketball, he doesn't lecture you about the size of the ball or the height of the hoop. He gives you a ball and you start shooting baskets. If you are learning to make a dress, you don't start by hearing about the theory of weaving fabric, but get started with scissors, pins, and patterns. This is the way it is with science in IIS. You get involved.

By now this is all starting to sound too good to be true. There must be a catch. What about grading? And those science tests to clobber you?

Like the ads say, "It's performance that counts." In IIS what you do in the laboratory is the most important part of your grade. You won't be memorizing long lists of chemicals or parts of the body. Those aren't science anyway. What counts most is how you do the investigation.

Still wondering about this science course? You have been promised things in school before, so you won't fall for this line too fast. That's all right. Science doesn't take anything for granted. It has to have proof. Come on in and try IIS. We can prove that this course is for you. All you have to do is try it!

Malvin S. Dolmatz

Harry K. Wong

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Idea 1
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Investigation 1

Do You See What I See?

This is a golf ball. Chi Chi Rodriguez is a champion at putting golf balls where they belong.

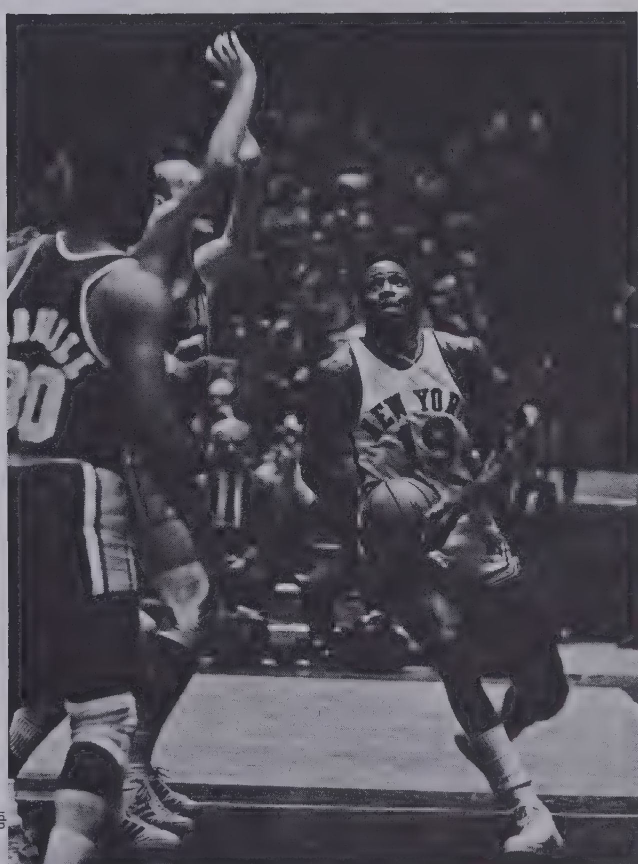
If you want to discuss basketball, take a look at Willis Reed.

How good are you at observing and describing things? Imagine that you are communicating with someone on another planet. He has never seen the Earth, much less a basketball game. How would you describe a golf ball or a basketball to someone who has never seen one?

Chi Chi Rodriguez

Eastern Airlines Photo

Willis Reed



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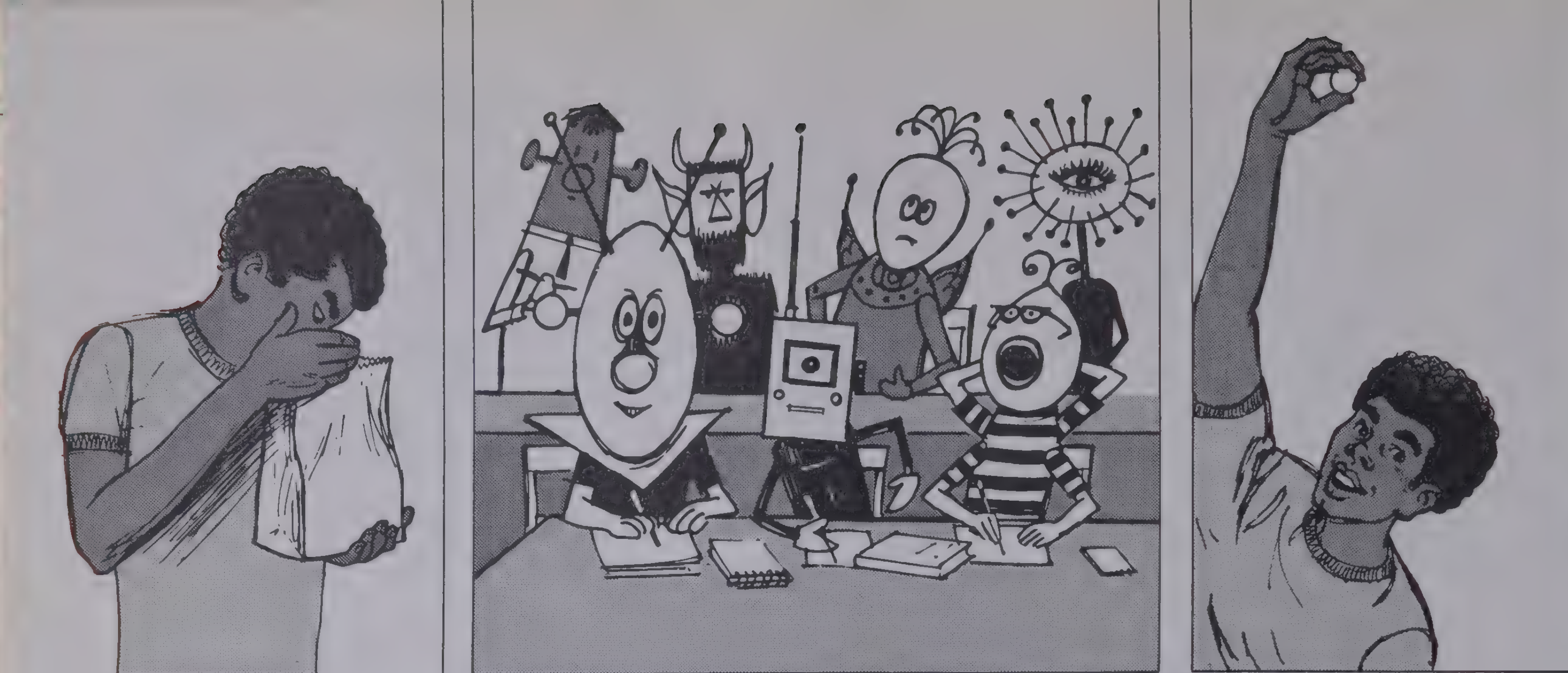


A. IT'S IN THE BAG

You will be given a paper bag with some things in it. Do not show the contents to anyone. The teacher will ask someone to select an object from his bag and to hide it in his hand. He is to describe the object to the class. He cannot give the name of the object or tell what it is used for. No one should ask him questions until he has finished his description.

Imagine that everyone in class is from another planet and names don't mean a thing. You are to describe, not name. As the object is described, look for it in your bag. Do not show what you selected to the rest of the class. When everyone is ready, someone will say: "Show!" Hold up your object.

Repeat this a number of times. The aim is to get everyone in class to show the same thing. You are an expert describer if you can get everyone to hold up the right object.

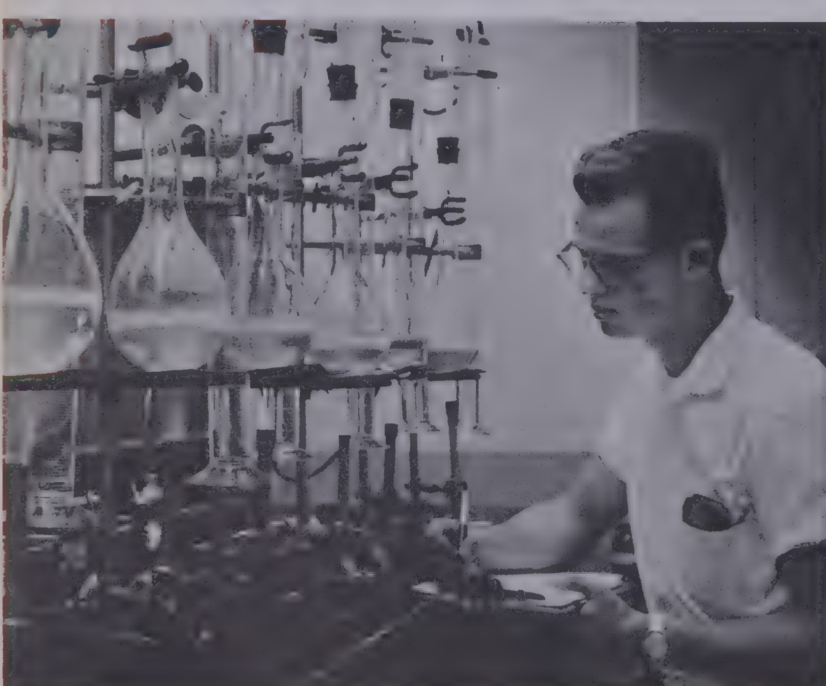


Photo Courtesy of Chas. Pfizer & Co., Inc.

1. Did everyone show the correct object every time? If not, why not?

2. What is necessary before everyone can show the correct object?

B. JOT IT DOWN

A scientist must be able to make brief but accurate notes on the thing he is studying.

You will be given another paper bag. Again, do not show the contents to anyone. The class will repeat the activity with the new set of objects.

Wide World Photos

3. This time *write* a brief description of each object on your data sheet. Write down the name of the object *after* it has been identified. The first one has been done for you.

4. Did everyone show the correct object every time? If not, why not?

5. What is necessary before everyone can show the correct object?

C. DO YOU JUMP TO CONCLUSIONS?

What you think you see depends on things you may have assumed.

6. Look at the picture above. What is happening to the man in the middle?

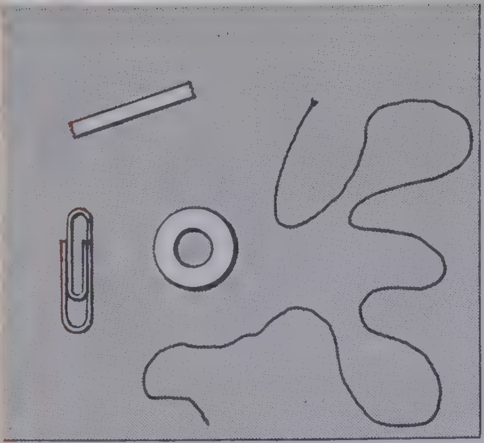
If you said the man in the middle is being arrested, you were wrong. Look carefully at the picture again.

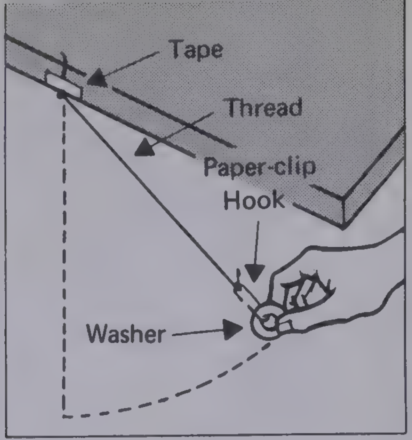
7. What do you see on the man in the middle? Now what can you say about him?

Did you find the small object that suggests what the man in the middle may be? If you did you are observant and you do not make hasty assumptions.

You've heard the saying: "He can't see straight." This means that a person can't see things as they are. A scientist has to see things as they really are.

Gulf General Atomic, Inc.





D. THE SWINGING LIGHTS

Can you observe accurately? Let's see. You will be given a piece of string about 18 inches long, some tape, a paper-clip hook, and a washer. Attach the paper-clip hook to one end of the string. Tie a knot 18 inches from that end of the string. Tape the end of the string without the hook to the edge of a table. Hang the washer on the hook.

Pull the washer back to the distance shown. Let it swing. Watch it. Concentrate on it as it swings freely. Try to get into the rhythm of its motion.

8. What do you notice about that rhythm?

If you're not sure, stop the washer and swing it again. This time pull the washer just a slight distance away from the vertical. Again, let it swing and watch it. Really get with its beat. Count its swings for a while, each time it reaches the top of its swing on the right.

9. What do you notice?

There is something about the beat of that swinging washer. Try several times more, pulling the washer back to many different positions. Each time, count out the beat.

10. Was the beat slower when you pulled the washer far back from the vertical?

11. Was the beat faster when you pulled it back just a little way from the vertical?

12. Tell what you have observed about the rhythm of the swinging washer.

Over 400 years ago a man in church noticed the lights swinging from the ceiling. He was puzzled by something. He went home and did the same experiment you have just done. In time Galileo—that was his name—made one of the basic discoveries in science.

13. What must a scientist be able to do well?

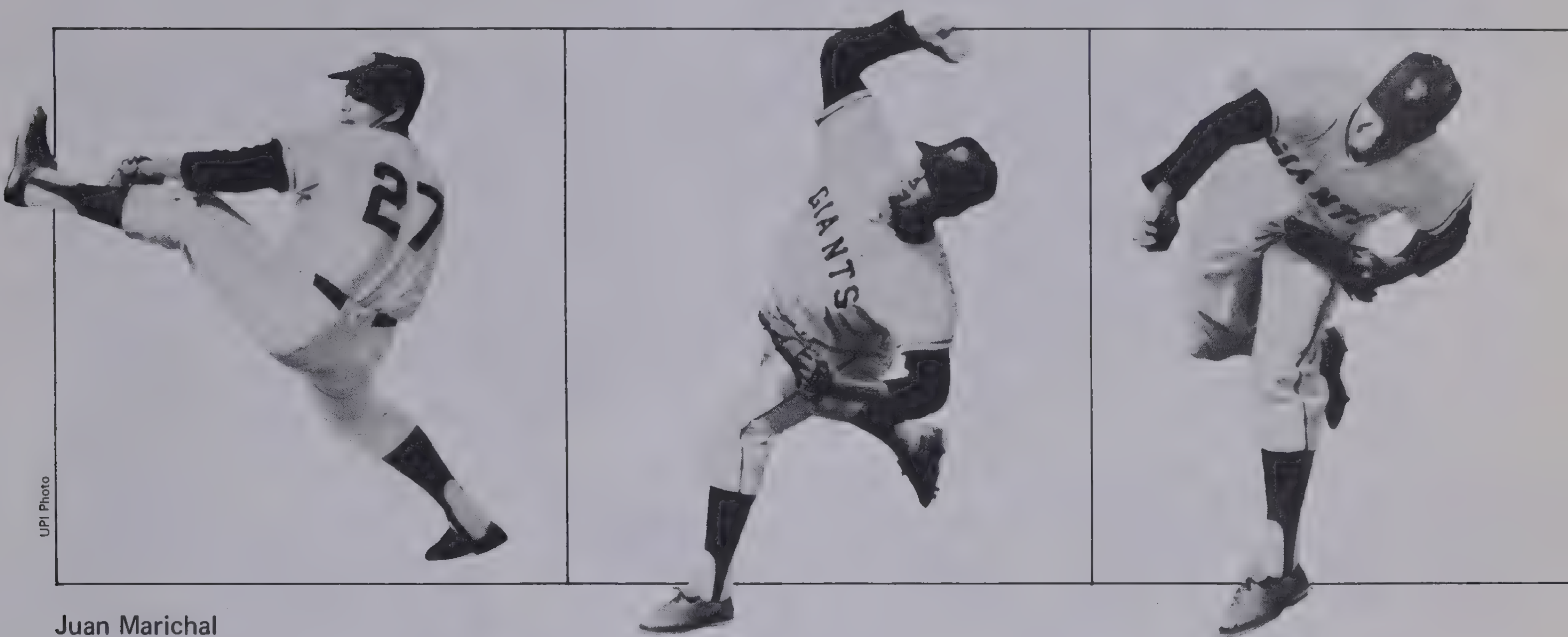
14. Why should you be able to do it well, also?

The following investigations are all like this one. From what you do yourself you will discover ideas on your own. We call a small, specific idea a *concept.*

CONCEPT SUMMARY. (In one sentence, tell the most important thing that scientists do.)

Investigation 2

It's a Regular Happening



UPI Photo

Juan Marichal

Juan Marichal seldom walks a batter. He takes a keen look at the strike zone.

Then there's Jerry West—a real deadeye!

Narinder Kapany has a good eye, too, but he doesn't play baseball or basketball. Dr. Kapany is a scientist. His company makes glass tubes, called fiber optics, that allow you to look inside an engine, or inside someone's stomach.

Wide World Photos

Jerry West

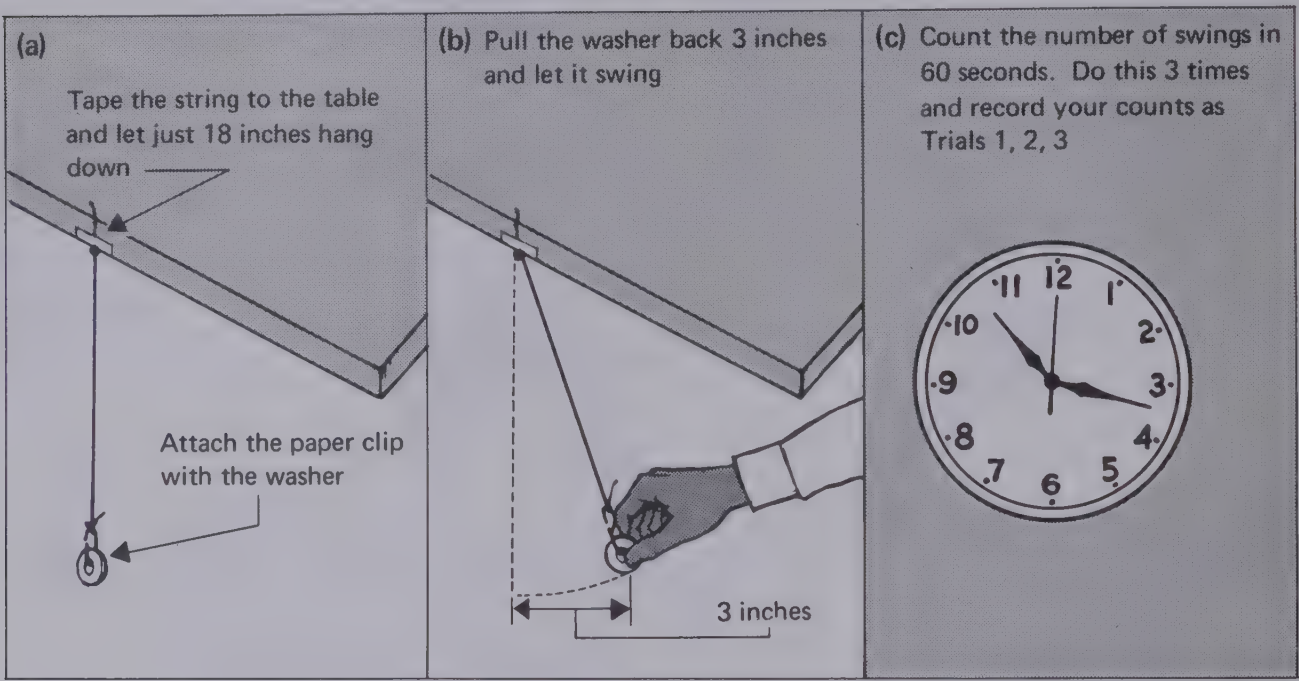
Narinder Kapany

Optics Technology, Inc.

In the last investigation you learned that scientists have to make accurate observations. But what are scientists looking for?

A. SWINGING AND COUNTING

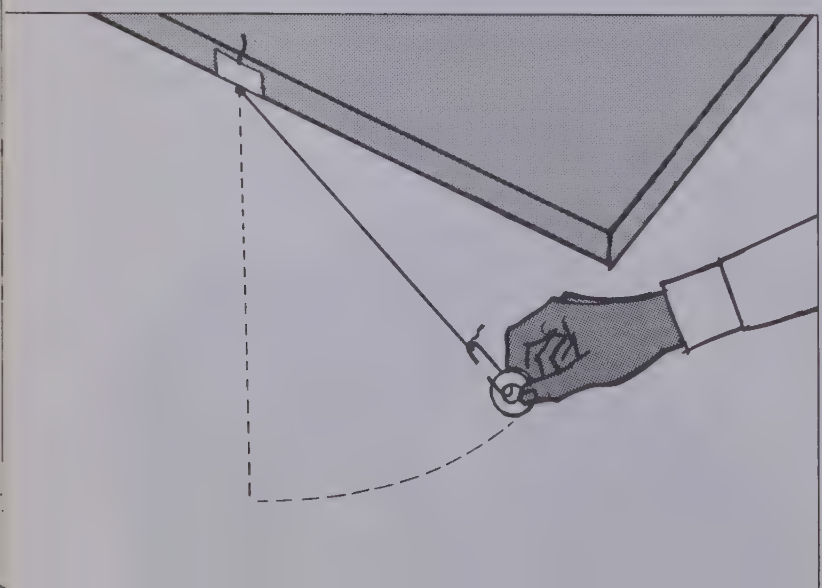
You will be given the string, paper-clip hook, tape, and washer, just as in the first investigation. What you will make is called a *pendulum.* Get with its beat, as you did in the first investigation. (Remember that a "swing" means the complete movement from the top right position, over to the left, and back to the top right again.)



1. What do you notice about the number of swings in Trials 1, 2, and 3?

2. If you were to make ten more trials, in exactly the same way, how many swings per minute do you think you would get on each trial?

Now pull the washer back about twice as far as in the previous trials. Again, count the number of swings in one minute. Record your counts as Trials 4, 5, and 6.



3. What do you notice about the number of swings in Trials 4, 5, and 6?

4. If you were to repeat the procedure a hundred more times, how many swings per minute do you think you would get?

5. What do you notice about Trials 4, 5, and 6, as compared to Trials 1, 2, and 3?

6. Compare the number of swings with the 3-inch pull and the longer pull. What do the other teams find?

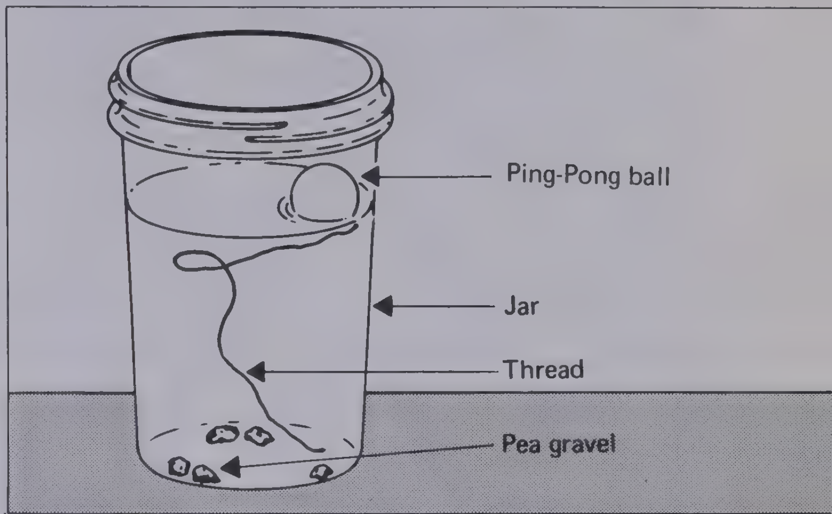
7. If a person in Norway were to do just what you have done, what count do you think he would get?

8. If a procedure remains the same in every way, then no matter how often you repeat it, what results will you get?


Norwegian National Travel Office

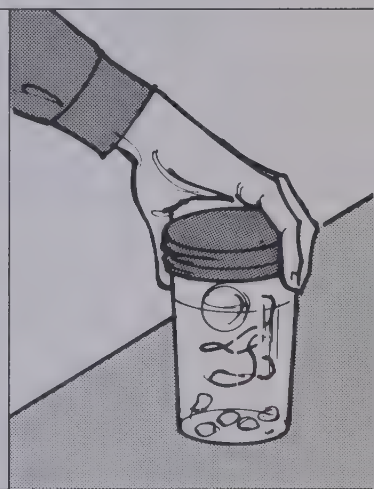
B. SHAKE IT UP

You will be given a jar full of water. In the water are some other things: a Ping-Pong ball, some gravel, and a piece of thread.



Shake the jar thoroughly. Set the jar down on its base.

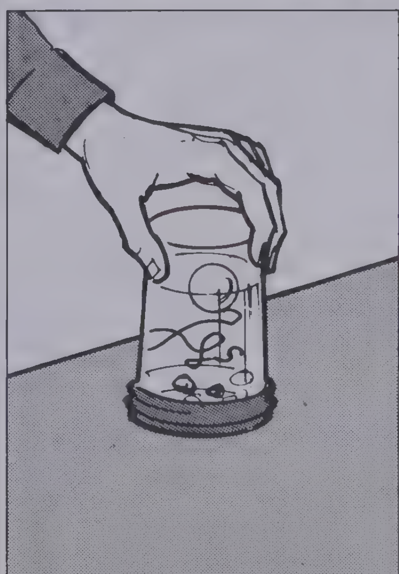
9. When they have stopped moving, how are the contents arranged? Which object is on top? Which is in the middle? Which is on the bottom?



10. Shake the jar again and set it down on its base. In what order are the contents arranged?

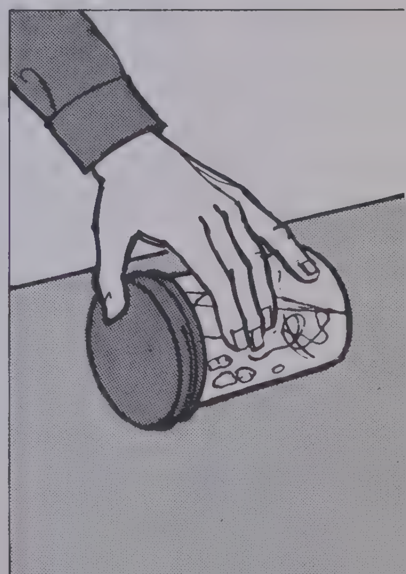
11. In what order would the contents be arranged if you did it again?

12. Shake the jar again, but set it down on its cap this time. In what order are the contents arranged now?



13. In what order would they be arranged if you did it again?

14. Shake the jar and set it down on its side. In what order are the contents arranged?



15. What happens when you repeat the same procedure?

16. Do you think the Ping-Pong ball would still float if you took it out of the jar and threw it into a lake? Why?

C. THE HOMEMADE SUBMARINE

You will be given a plastic bottle full of water with an eyedropper in it. This is known as a Cartesian diver.

17. Squeeze the bottle. What happens?

18. Stop squeezing. What happens?

19. Repeat "17" and "18." Describe what happens.

20. No matter how often you squeeze and let up what will the results be?

21. What results do you predict that everyone else in the class is getting?

22. If someone in Argentina were to do what you have just done, what results would he get? Explain why.

D. THE SAME OLD THING

23. You have just discovered a basic concept of science. It is about doing the same action, in the same way, with the same materials. What is this basic concept?

24. Once the way something happens has been discovered and explained, we know the way it happens will always __?__

CONCEPT SUMMARY. (This investigation was not merely about pendulums, floating Ping-Pong balls, and so on. Explain what science tells us about results when we repeat events.)

Investigation 3

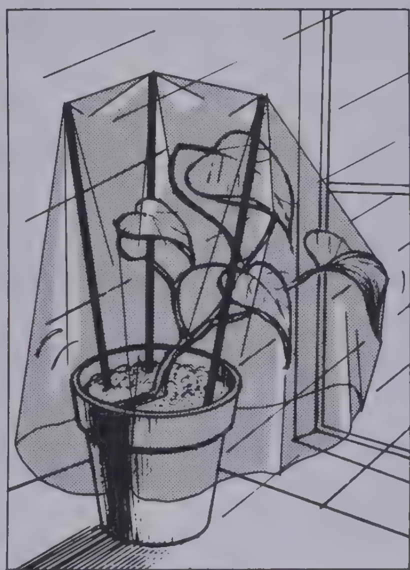
What Do You Predict?

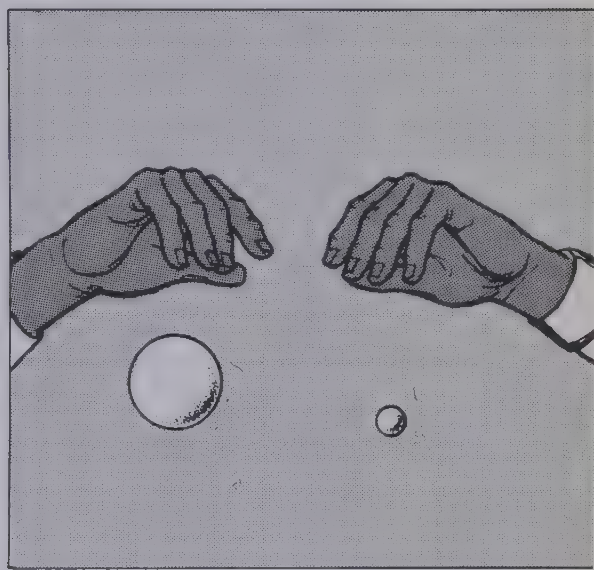
What do you predict will happen if a boy drops out of school?

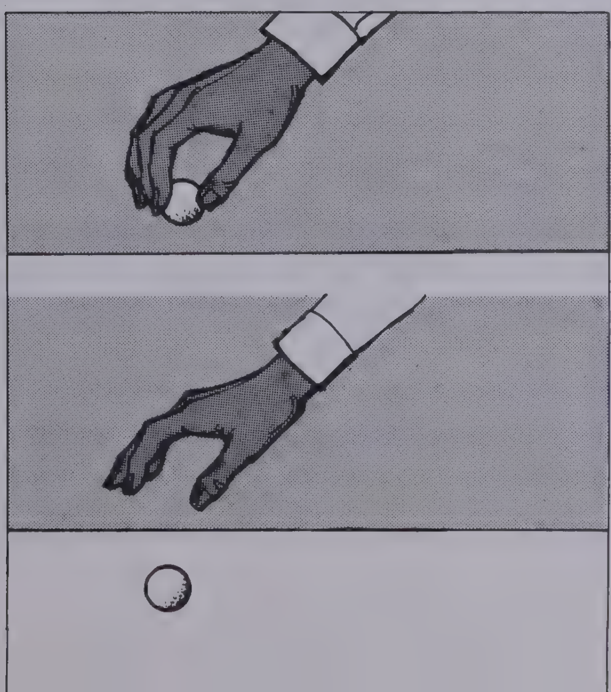
What do you predict will happen if a plant is grown under colored light?

What do you predict will happen if a large ball and a small ball are dropped at the same time from the same height?

Shelton from Monkmeyer Press Photo Service







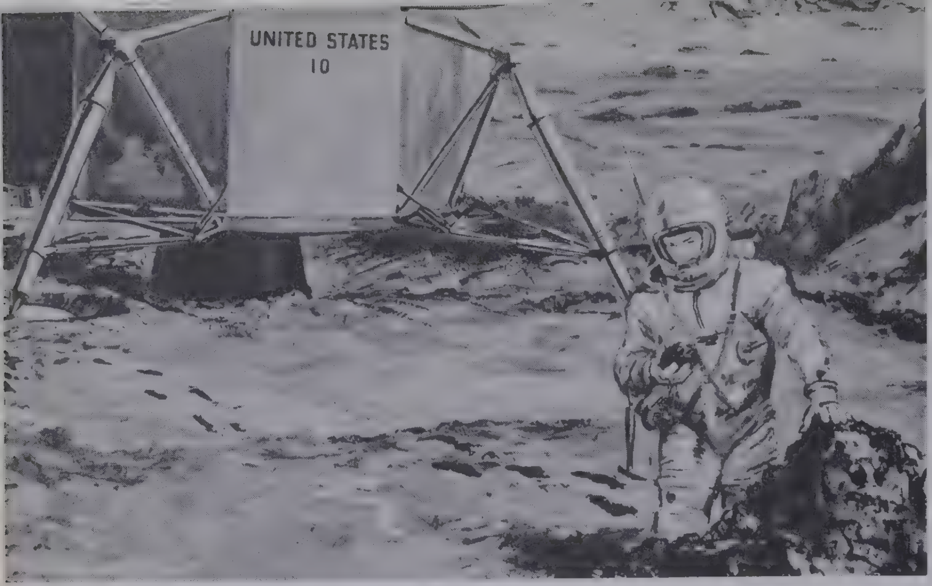
A. TAKE ONE

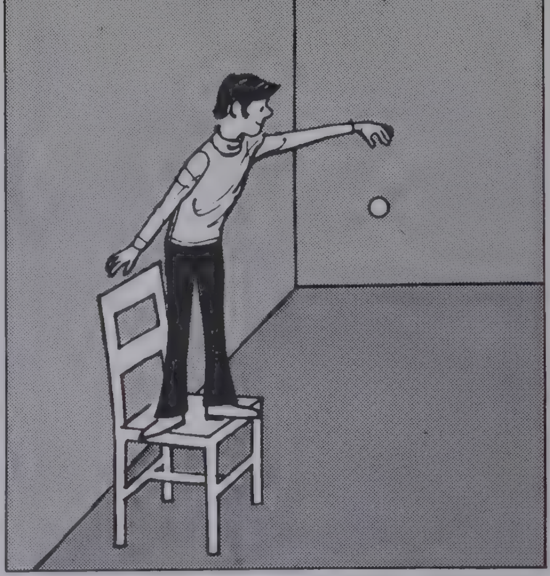
You will be given the same bag of balls you used in the first investigation.

1. Take any one ball from the bag. Hold it in your hand. Let go of it. What happened?

2. Take the same ball again. Before you let go of it, make a prediction about what you think will happen.

3. Why did you make the prediction that you made? Hint: What did you learn in Investigation 2?





4. Now release the ball. What happened?

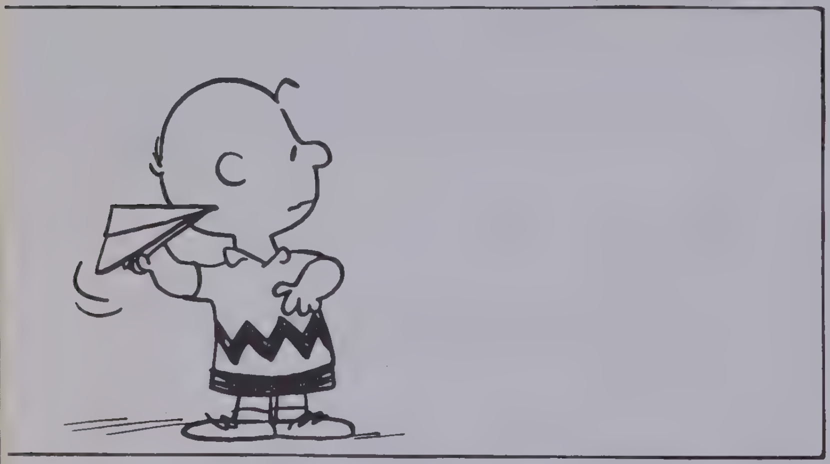
5. Repeat the procedure several more times. What happened each time?

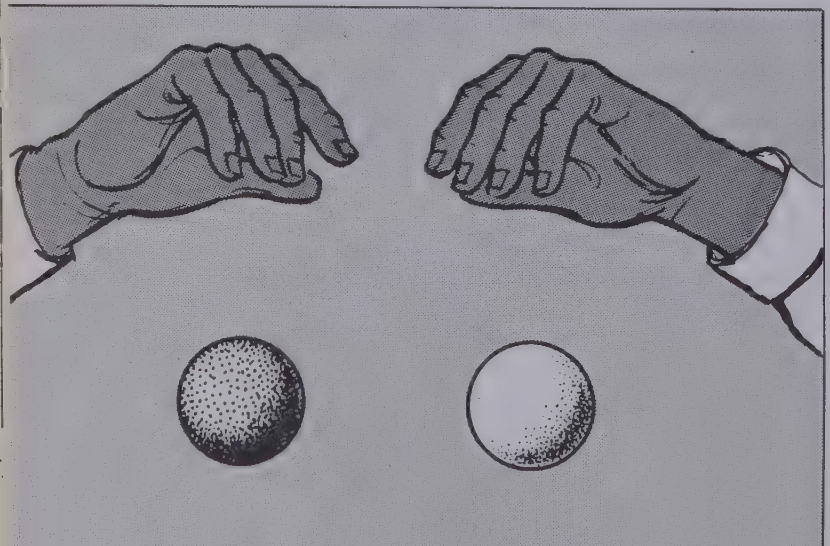
6. If you were to release the ball anywhere on earth, or even on the moon, what would happen?

7. If you took a different ball, stood on a chair, and released that ball from higher up, what do you predict would happen? Try it.

8. What do you predict would happen if you released the ball a thousand—a million—times?

9. Will your statement always hold true if the conditions remain the same? Explain.





B. TAKE TWO THAT ARE THE SAME

What do you predict will happen to Charlie Brown's airplane?

Take two balls of approximately the same size and weight. The question is: Which ball will hit the floor first, if you let them both go at *exactly* the same time from *exactly* the same height?

10. Before you try it, make a prediction as to what you think will happen. (You will not be graded on the accuracy of your predictions. So don't be afraid; go ahead and predict!)

11. All right; now release the two balls at the same time, from the same height. What happened?

12. Repeat the procedure at least three more times—more if you like. Does the same thing happen each time? Why?

13. If you were to repeat the identical procedure a billion times, under the same conditions, as suggested by the film strip, what would happen? Why?

14. You have made many predictions. Did you get them all right? If so, it is because you have observed something about the world. What is it?

C. TAKE TWO NOT THE SAME

Curiosity was born when man was born. The earliest prehistoric man wondered about the lightning in the sky, about the cold or warmth that surrounded his naked body, about the ability of birds to fly, about the nature and habits of animals.

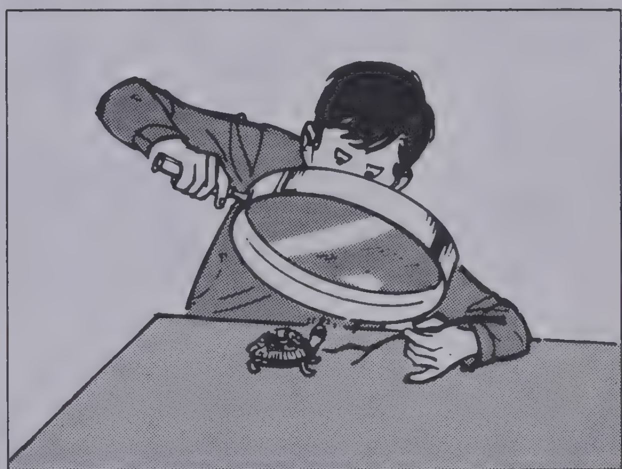
Man has not stopped wondering.

People who succeed are people who wonder about things. They ask questions. They look actively for the answers.

Are you a curious person? If so, you will like science. Science is the excitement of finding out about the natural world. And the only way to find out is to turn on your curiosity; then it will turn you on.

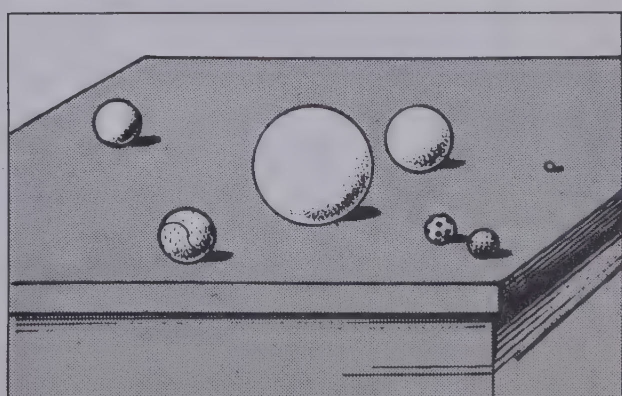
A. T. & T. Photo Service

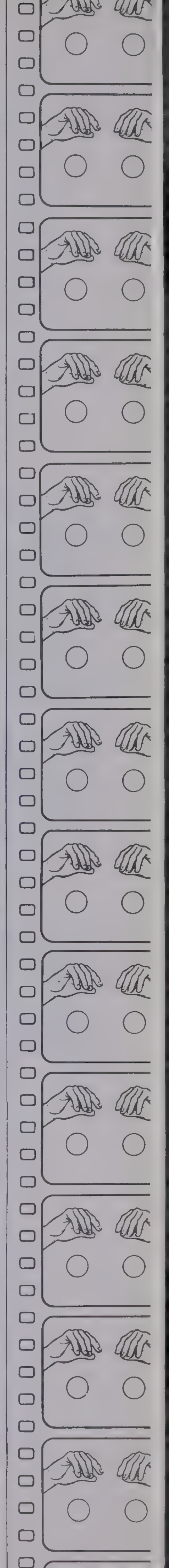
You still have a collection of balls. There are other things about balls besides size and weight. They can be hard or soft, hollow or solid, rough or smooth. They can be dropped from different heights, at different times.



You have done two things so far in this investigation: (a) you have dropped 1 ball; (b) you have dropped 2 balls of about the same size and weight, from the same height, at the same time.

Be curious about what would happen if you did other things with them. Do all balls bounce to the same height? Do they all even bounce? Do heavier ones bounce higher? Do hollow ones fall more slowly?





15. List some problems that you could investigate with the balls. The first has been started for you.

Curiosity and observation lead to questions; questions lead to problems. To solve the problems the scientist does something that seems unscientific. He makes a guess—an educated guess. That guess is his best prediction of the solution to his problem.

So the steps are as follows:

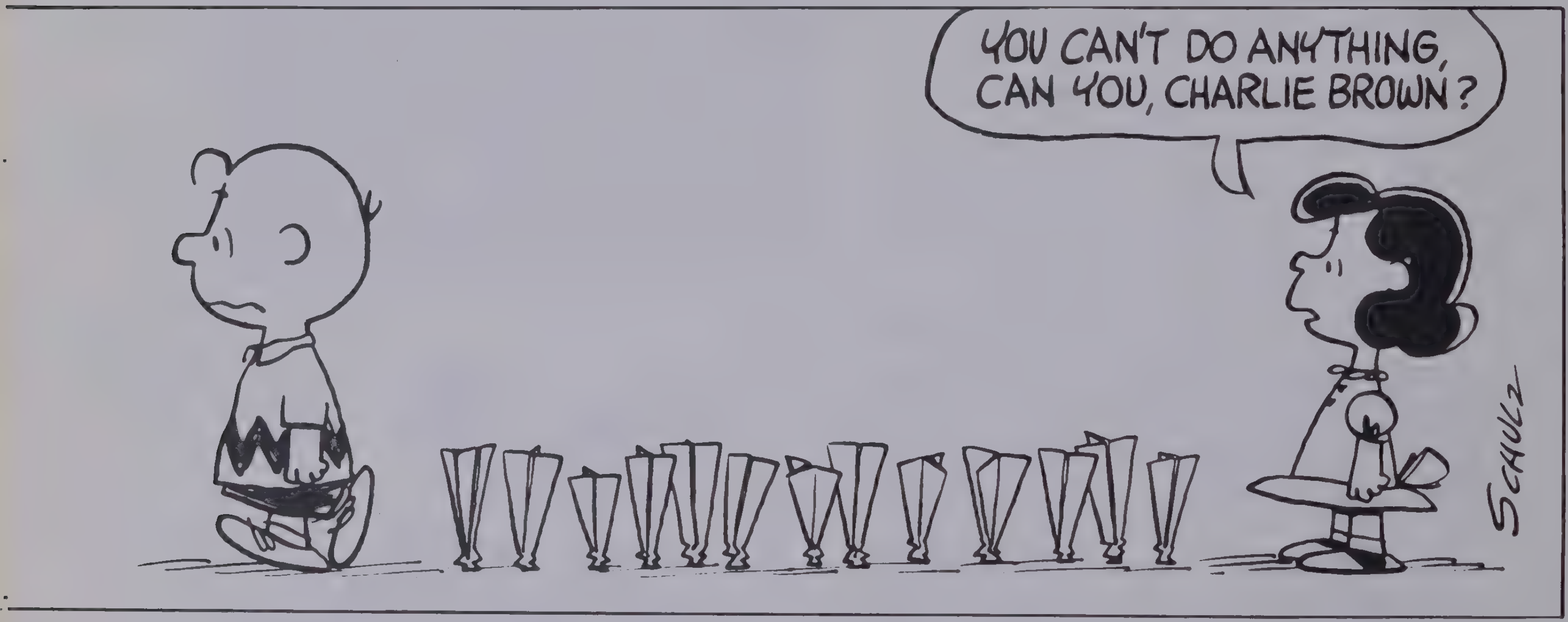
(a) "What do I want to know?" (THE PROBLEM)

(b) "What do I think the answer is?" (THE PREDICTION)

16. What do you predict would happen if you were to investigate each of the questions you wrote at "15"? List your predictions in the same order as the questions. (Don't say that the balls will hit the ground and bounce. Predict more than that.)

17. What does a scientist do after he has stated a problem?

CONCEPT SUMMARY. (Tell what you discovered about how scientists work.)



Investigation 4

Put Up or Shut Up

The scientist is curious. He looks at the universe to see what the facts are. Then he makes a prediction. About 400 years ago Nostradamus, the prophet, predicted all kinds of happenings. But he played it cool. His predictions were about things far in the future.

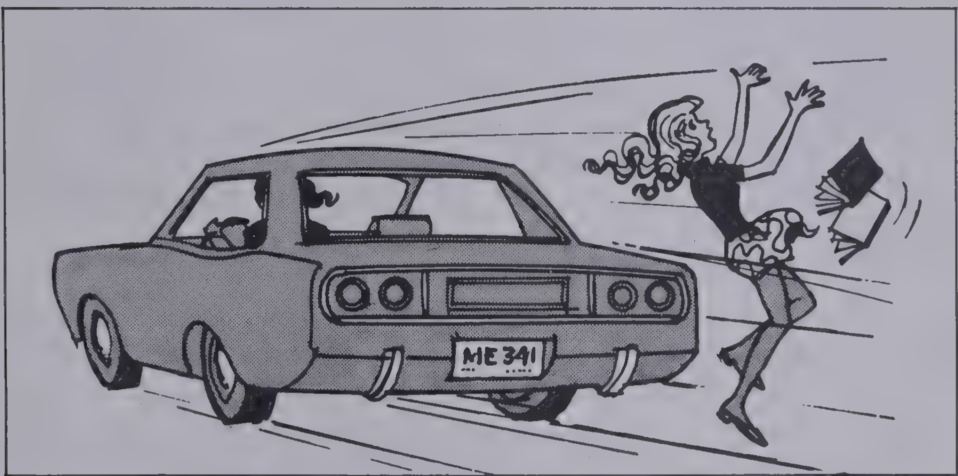
Modern scientists don't have it so good. They have to produce now. The scientist must put his predictions on the line.

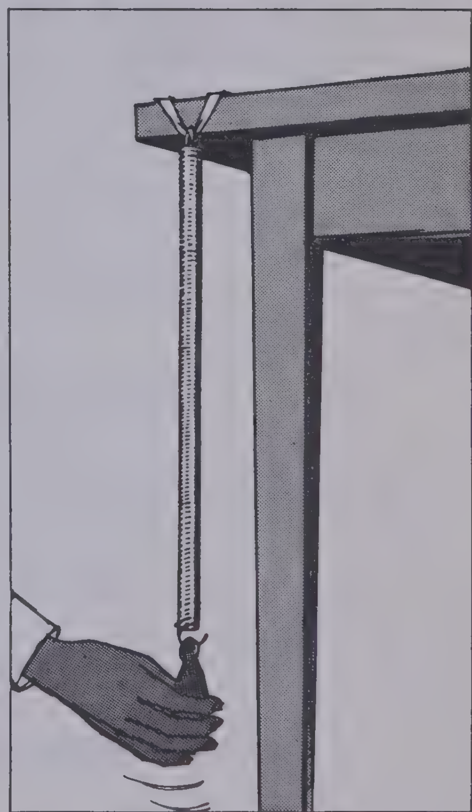
Rare Book Division, The New York Public Library

A. SPRING HAS SPRUNG

1. After making a prediction about what will happen, what is the next step?

You make and test predictions all the time. Every time you cross the street you test the prediction that you can make it before a car comes. It's a prediction you can't afford to be wrong on.





Let's try something a little less exciting. Suppose you hang a weight on the end of a spring, then pull the weight down about 1 centimeter and let it go. The weight goes bouncing up and down. The farther down you pull the weight to start it, the higher it will bounce.

2. Let's start with an 8-ounce sinker. Count and record how many times a minute the weight hits the bottom of its bounce.

3. Predict whether a 3-ounce sinker would bounce faster or slower?

Hang the 3-ounce sinker on the spring. Pull it down one centimeter and let go. Count its bounces carefully for one minute.

4. What happened?

Is 1 test enough? Scientists are rarely satisfied with 1 trial.

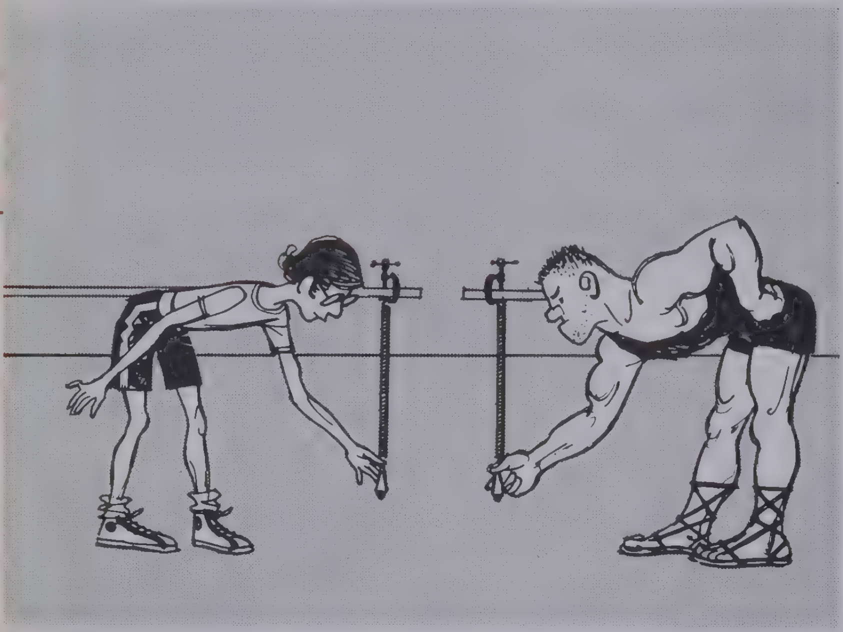
5. Why not settle for 1 time?

6. Try both sinkers again. What results did you get this time?

7. What would happen if you tested the same thing again? And again? And again?

8. How did your prediction come out?

9. If your prediction was wrong, what did you learn anyway?



B. STRETCH

Do muscles make a difference? Would Tarzan and Puny Pete both get the same results?

10. Does it matter who pulled the weight down 1 centimeter?

Let's ask another question. If the weight were pulled down 3 centimeters would it bounce up and down more times a minute than the same weight pulled down 1 centimeter?

11. What do you predict?

12. Now that you have predicted, what is the next step?

13. Try the same sinker pulled down 1 centimeter and then pulled down 3 centimeters. What results do you get?

14. Why should you try it again?

15. Keep trying until you are sure. What are your results?

16. What is testing a prediction called? Why do we test a prediction?

CONCEPT SUMMARY. (Tell what happens after a scientist has made his prediction.)

Investigation 5

Bigger Than What?

The scientist enjoys the excitement of testing his prediction. The purpose of his experiment is to *provide evidence that will either support or reject his prediction.* The evidence he collects helps the scientist to reach his conclusion. So the method of science consists of asking the questions:

PROBLEM: What do I want to know?

PREDICTION: What do I think the answer will be?

EXPERIMENT: How can I tell if the answer will be what I predicted?

DATA: What happened when I tested my prediction?

CONCLUSION: What do the results of the experiment mean? Is the problem solved?

Still Upward Bound, May-June, 1968

What Does He Want to Know?

A. DO YOU SEE WHAT I SEE?

In the last investigation you bounced weights on springs. You found out that either heavy weights or light weights bounced faster. Could something else beside the weights *control* their speed? An experiment should provide evidence that will either support or reject the prediction. But you can collect the wrong evidence and never know it.

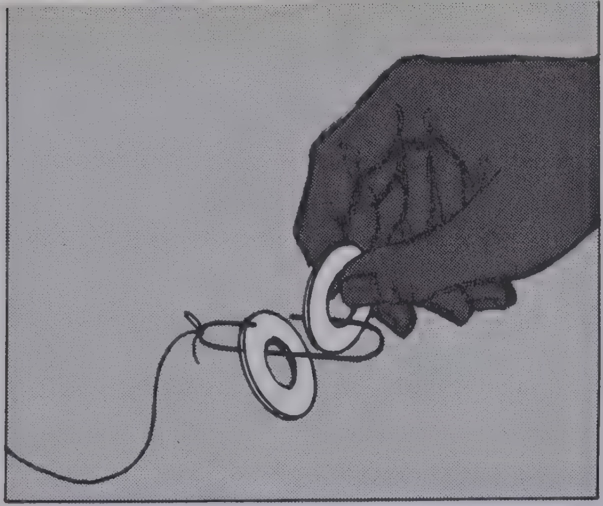
You will be given the familiar pendulum you used in Investigations 1 and 2.

Attach the pendulum to the table. Pull it back 3 inches and let it swing. Do this 3 times and record the swings per minute as Trials 1, 2, and 3.

1. What do you notice about the number of swings in Trials 1, 2, and 3?

Pull the pendulum back different distances. Let it swing. Record the swings per minute as Trials 4, 5, and 6.

2. What is the relationship between the distance the string is pulled back and the number of swings per minute?



Add another washer to the hook and set the pendulum swinging. Count the number of swings per minute 3 times, and record your counts as Trials 7, 8, and 9.

3. What do you notice about the number of swings per minute in Trials 7, 8, and 9, as compared to Trials 1 through 6?

Add a third washer to the hook and set the pendulum swinging again. Count the swings per minute 3 times and record your counts as Trials 10, 11, and 12.

4. What do you notice about these trials as compared to all previous trials?

5. How many swings per minute do you think you would get if you added more washers?

6. How does the weight at the end of a pendulum affect the number of swings per minute?

7. How does the distance a pendulum is drawn back affect the number of swings per minute?

8. What kind of results do you predict someone in Ghana would get if he did the same experiment under the same conditions?

9. How many swings per minute do you predict that your classmates have gotten on Trials 1 through 12, as compared to your results?

10. Just to be sure, check with at least 4 other students. Are they getting the same number of swings per minute that you did?

11. Why is that? Remember, you're trying to learn what a *controlled* experiment is.

12. Think of all the class results together, as if they were all part of 1 experiment. Was it a controlled experiment? Explain.

B. WHAT'S A SEYMOUR TIRE?

If you've caught on to what a control is, you should have no trouble answering the following questions.

13. What is wrong with this statement? "Seymour tires last 54% longer."

14. What is wrong with the following statement? "Bigger balls bounce higher."

15. In conclusion, explain what a controlled experiment is.

CONCEPT SUMMARY. (Tell what all experiments need.)

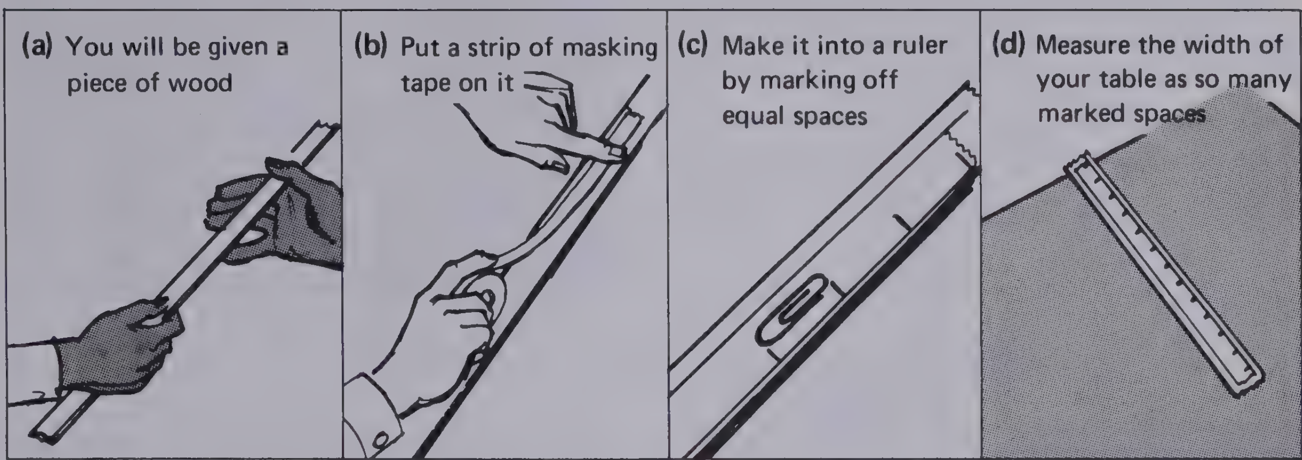
Investigation 6

Standard Size

In your last investigation you learned the importance of having a control in your experiments. A control is a check or comparison to the experiment. It is an identical experiment, except that it lacks the one thing being tested.

A. IT'S 33 TIDDLYWINKS WIDE

You are going to make a homemade ruler. You may use any unit you like. (The unit is the distance, or space, between any two of the main marks on a ruler. Most ordinary rulers use the inch as their unit.) Your unit may be the width of your thumb, the length—or width—of a paper clip, the diameter of a quarter, or a nickel, the width of a stick of gum, anything you like.



1. What units did you use?

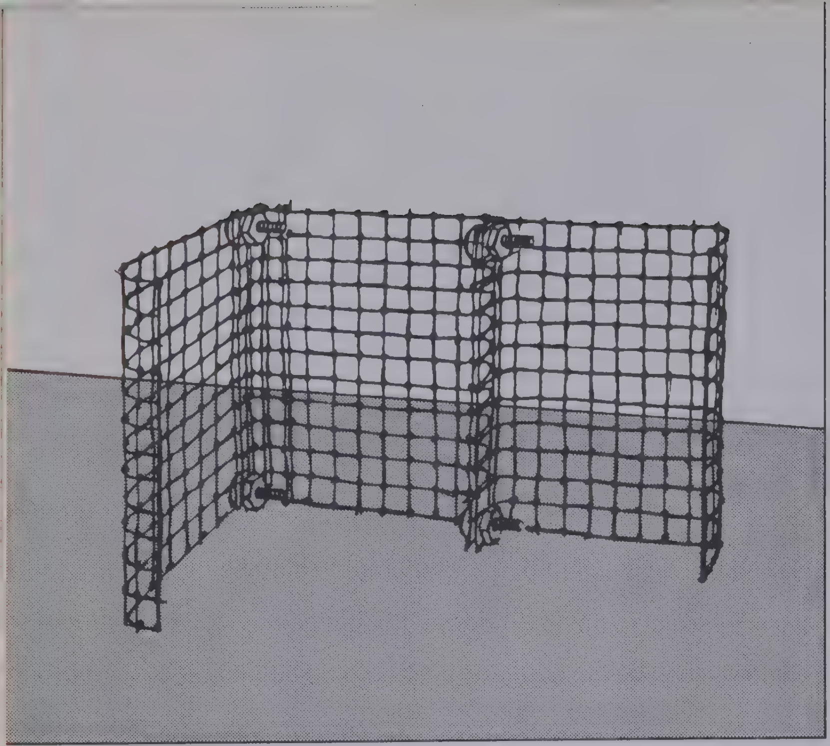
2. What was the width of your table in your units?

3. In the boxed space on the data sheet, jot down the figures giving the widths all your classmates got for their tables, using their units. Don't bother to tell what units they used—just give the numbers.

4. What do you really think about the widths of all the tables?

5. Do the figures in the box at "3" show that all the tables are the same width?

6. What should we do in order to have the answers to "4" and "5" agree?



B. BOLTS AND NUTS, NUTS AND BOLTS

Agreeing on rulers is important, but it isn't everything. Two groups could use the same ruler unit and still have confusion. Work on this construction project and see.

Here are the parts of a toy fence. Put it together with the nuts and bolts. You don't need tools. How are things going?

7. Put the bolt just at the edge of the nut so that you can see the threads of both together. What do you think the problem is?

Try swapping bolts with a table next to you and see what happens.

8. Take 1 of each kind of bolt. Count the number of threads in a quarter-inch. How do they compare?

9. Why is it necessary to have standard bolt sizes and numbers of threads per inch?

When you buy film, 135 or 120—or some such number—is on the box. You use that number to get the right size film for your camera.

10. Why are standard film sizes necessary?

Courtesy of the Eastman Kodak Company

11. Why are standards important in communications and commerce?

C. STANDARD OPERATING PROCEDURE

12. If you go to the music store and buy a record, can you be sure it will fit your player? Why?

13. So we have the standard meter, standard time, the standard ounce, and others. What are standards, and why do we need them? How did we get them in the first place?

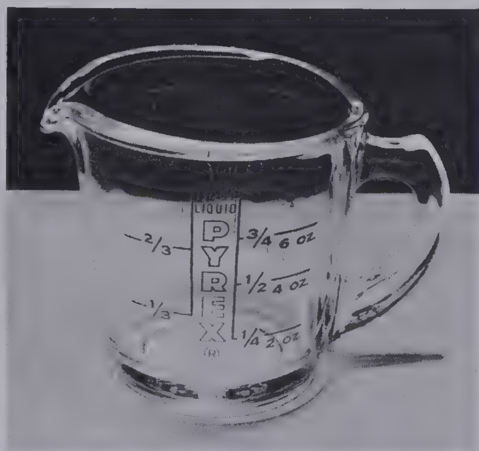
CONCEPT SUMMARY.

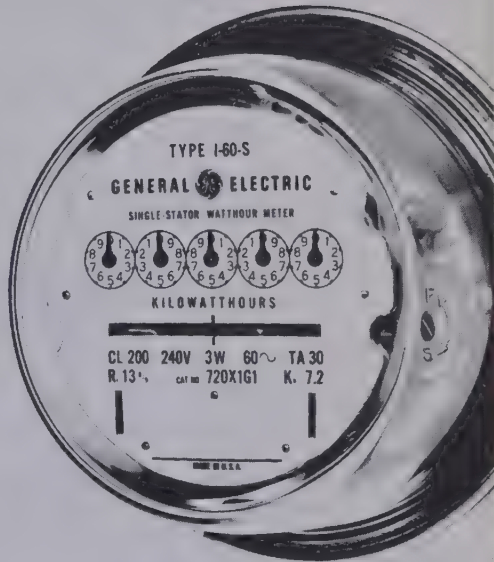
Investigation 7

Oh, It's Down Yonder

You now know that we need standards. Standards are necessary if people are to trade and communicate in accurate terms.

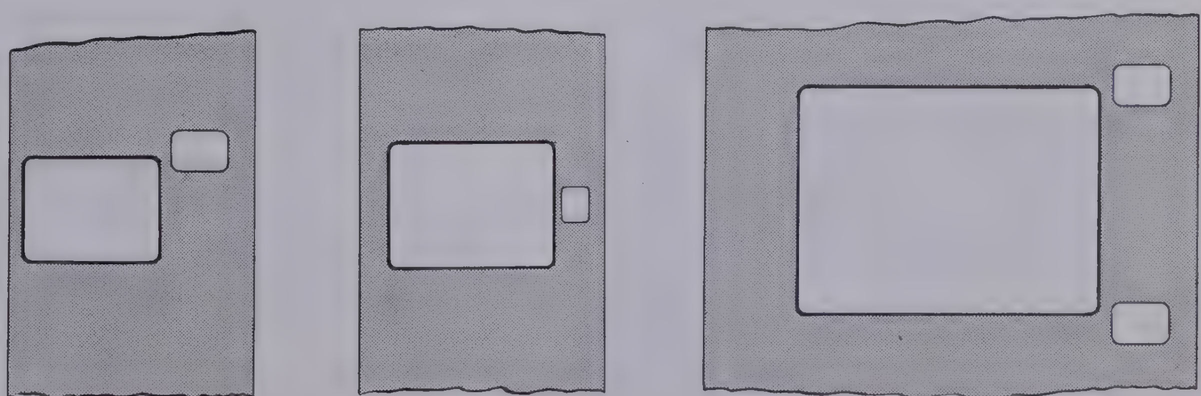
Ohio Dept. of Highways





Can you imagine the confusion if no one agreed on a quart, a mile, a pound, or a watt?

You take other standard measurements for granted, like the millimeter used in movie film sizes. Millimeters are from the metric system. People who own foreign cars buy metric wrenches and sockets.



Regular 8mm film — Super 8 film — 16mm film

A. THE NUMBERS GAME

Look at the numbers we use. You have gone through this in math a zillion times. Everything is in tens. Not twelves, or thirty-sixes, or five thousand two hundred eighties; just tens, hundreds, and thousands. So why measure in twelves, thirty-sixes, and so on? Most people don't!

Go ahead: measure with tens, hundreds, and thousands. Someone has already worked it out for you!

1. What do we need for any measuring system?

You will be given a meter stick. Compare it with the diagram and answer the following questions.

2. You can see lines dividing the stick. How many numbered spaces are there?

3. If you had to do some arithmetic, would you rather multiply by 12, 36, or the number in question 2?

4. Look at the tiny spaces on the meter stick. How many spaces are there between 5 and 6?

5. If you had to divide a number, would you rather do it by 8, 16, 32, or the number in question 4?

Now that you have all these nice easy divisions of a meter, you have to call them something.

6. What do you call a hundredth part of a dollar besides a penny?

7. With a clue like that in question 6, what would you call a hundredth part of a meter?

8. Some states once used sales tax tokens worth 1/1000 of a dollar. They were called mills. What are the tiny divisions on the meter stick called?

9. How many of them are there in a meter?

10. Work with a lab partner to measure your height. Use the meter stick and stand against a wall. What is your height in meters?

11. What is it in centimeters?

12. In millimeters?

13. Now compare to our English system. What is your height in inches?

14. What is it in yards?

15. Which system has the easiest arithmetic, the metric or the English?

B. TAKE A BIG STEP

Little divisions are nice, but what if you want to travel? You don't measure the distance from New York to Chicago in inches, and no one measures the distance from Paris to Rome in centimeters.

Look at the highway signs from outside the U.S. When you drive along the roads of most countries in the world, the distances are not marked in miles. They are marked in distances equal to 1000 meters.

16. Putting *kilo* in front of something means "times 1000." Usually it is abbreviated to just *k*. What does the *km* on these signs stand for?

17. How many meters are in one km?

18. There are 5,280 feet in a mile. Would you rather divide by 5,280 or by 1000?

19. How do you multiply by 100?

20. How do you divide by 1,000?

21. How can you convert from 2 meters to centimeters?

22. How would you change 67,000 meters to km?

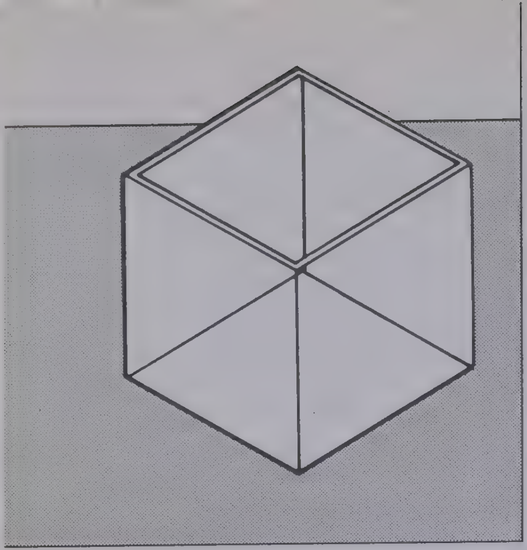
23. List the four major units of distance in the metric system, from smallest to largest.

United Nations

dpi

C. MILLIMETERS AND MILLILITERS

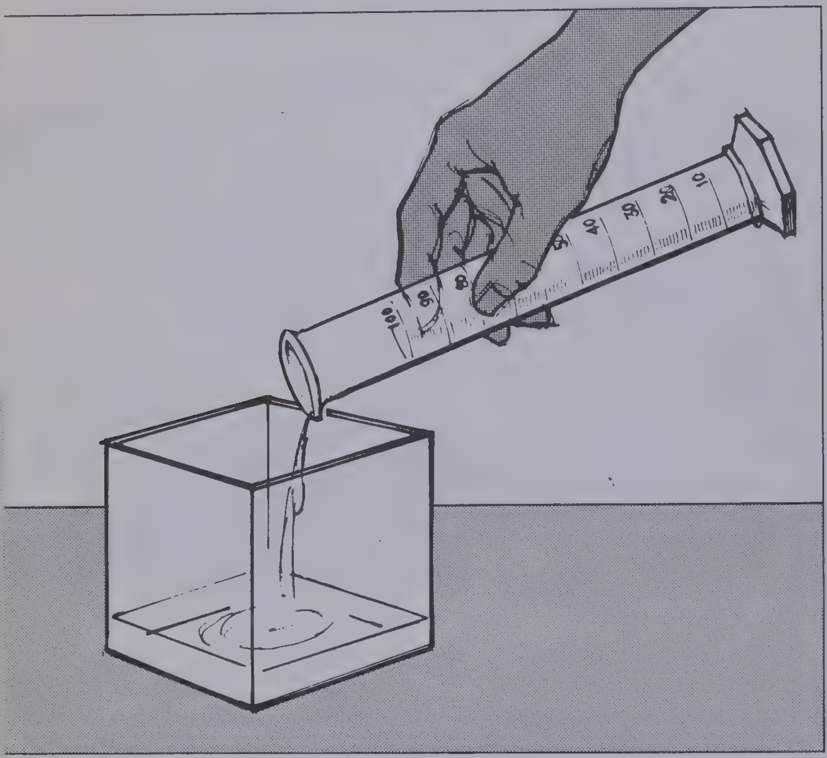
Measuring volume is just as easy. You only have to know one word, *liter*.



24. If the liter is the unit of volume, what would you call one-thousandth of a liter?

25. Your teacher has a large plastic cube. What do you know about a cube's length, width, and height?

26. Your teacher will measure one side of the cube in centimeters. Calculate the volume of the cube in cubic centimeters (cc). (Remember that volume equals length times width times height.)



27. The cube will be filled with water using a graduated cylinder. How many milliliters of water does the cube hold?

28. What do you notice about the numbers in your answers to question 26 and question 27?

D. THINK METRIC!

A new girl checks into class. The boys all look up. The first of the data anyone gets is: She is 1720 millimeters tall.

29. For a girl, is she tall, short, or about average?

30. If the *gram* is the unit of weight, what would you call a thousand of them?

31. The new girl weighs in at 61 kg. How does this compare with your weight or your girl's weight?

32. Find out what a few others in your class weigh. Put their weights in the box on the data sheet.

33. Now you know what some others weigh. You can see how they look. Knowing her height, is the 61 kg girl fat, thin, or about right?

E. HOW MUCH DOES MILK WEIGH?

In the metric system, the measure of distance, volume, and weight are all related.

34. Weigh a dry graduated cylinder. Record its weight.

35. Fill the graduated cylinder to the 100-milliliter (ml) mark. Weigh the graduated cylinder and the water. Record.

36. How much does the water weigh?

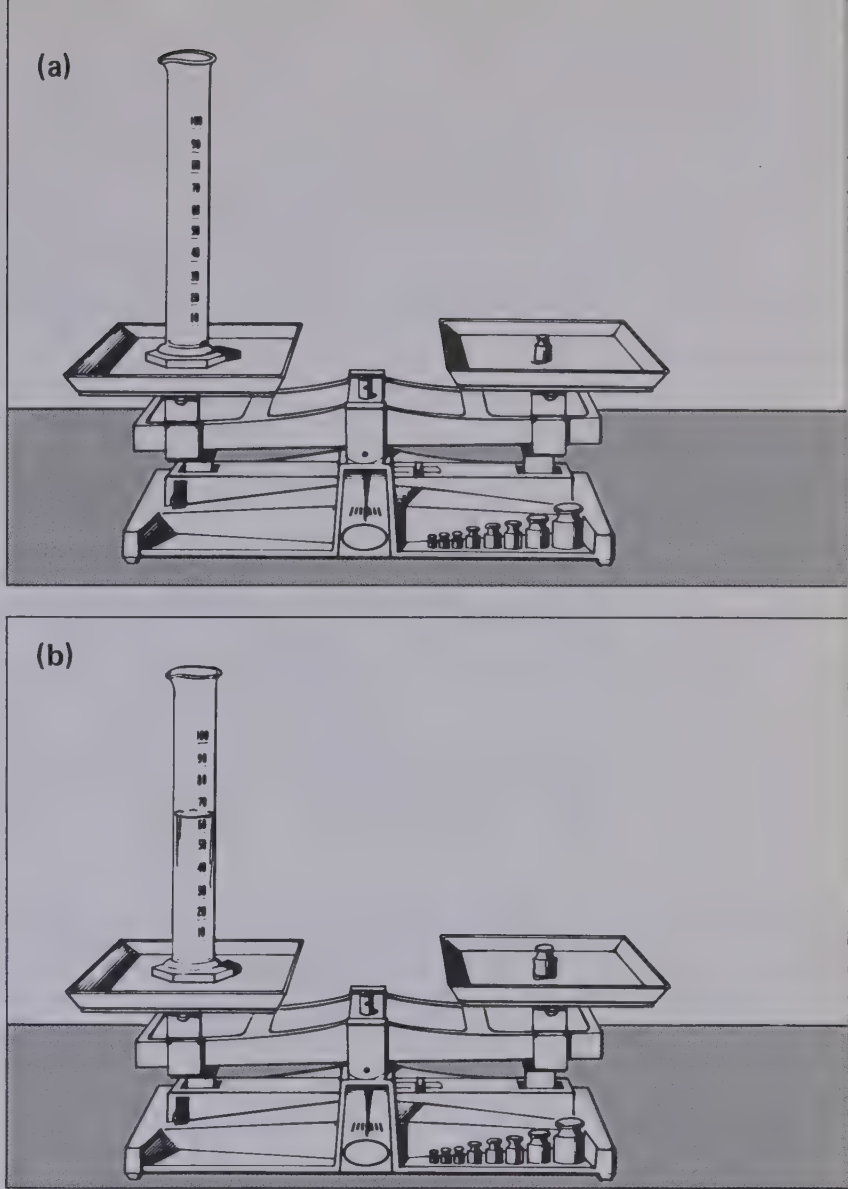
37. What volume of water, in cubic centimeters, was put into the graduated cylinder?

38. How much does a cubic centimeter of water weigh?

39. You will be given a very small plastic cube-shaped container. Weigh the container and record the weight?

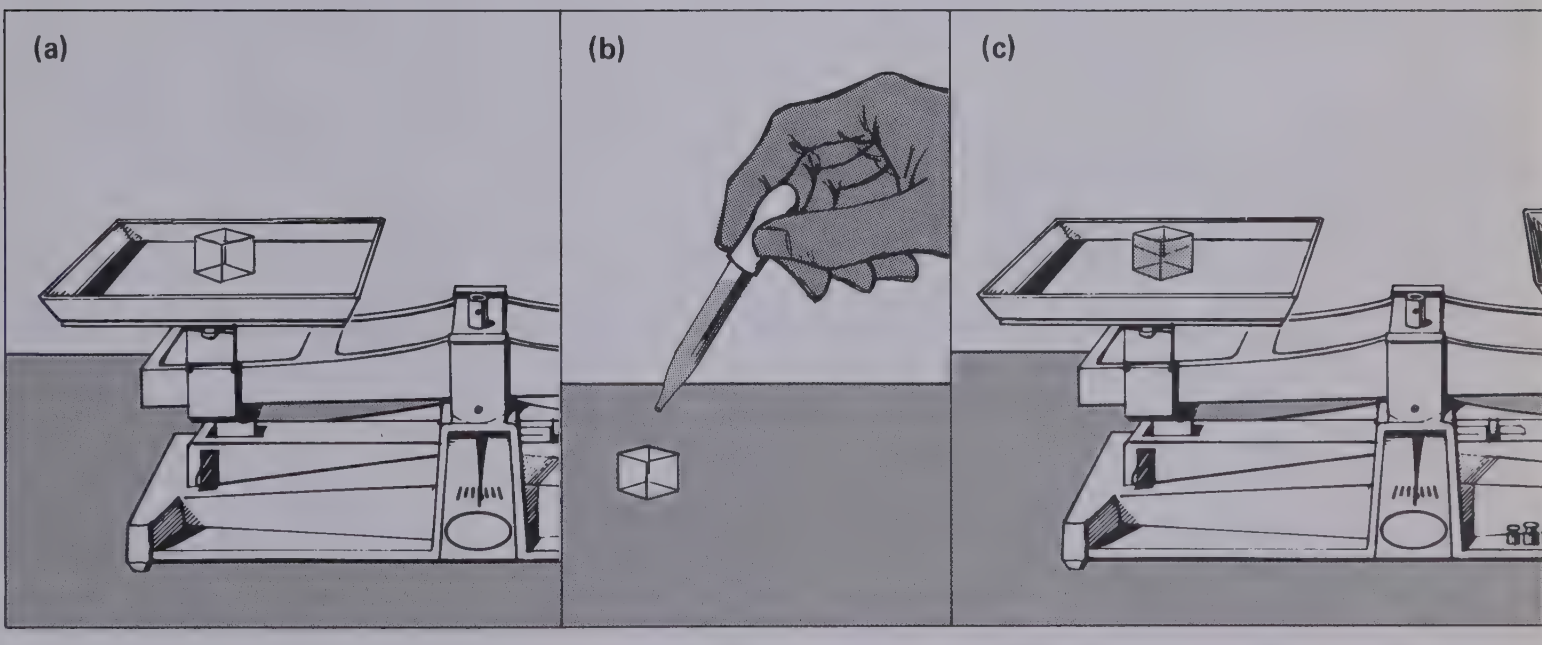
40. Using an eyedropper, fill it carefully with water. Weigh the container plus water. Record.

41. How much does the water weigh?



42. How much water do you think is in the container? (Use the correct unit of volume.)

43. How many times would you have to fill this container to get a liter of water?



F. METRIC OR ENGLISH?

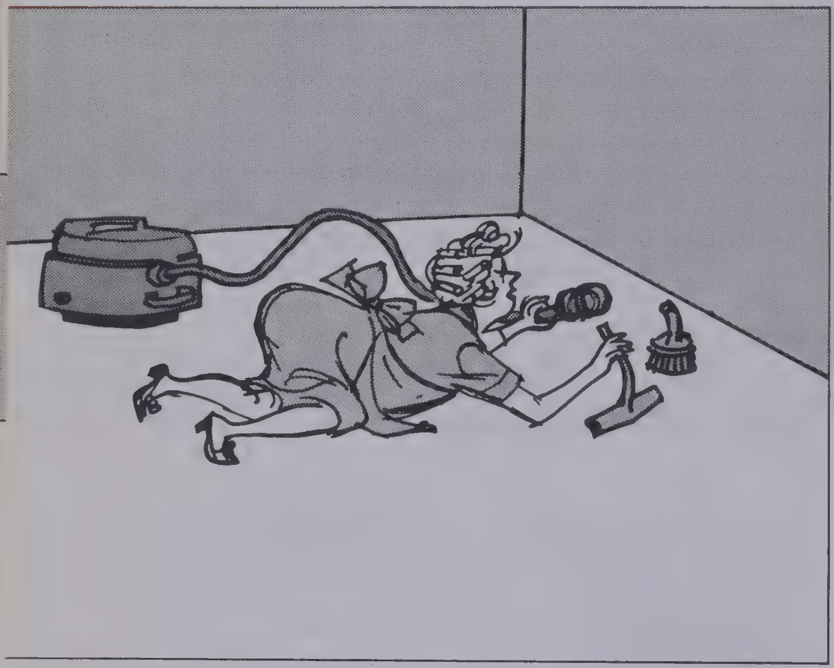
44. Now that we have all agreed on a standard unit of measurement, measure the width of your table again. What is its width in millimeters?

45. Centimeters?

46. Meters?

Once you get used to the metric system, it's easier to use than the English system. In metric, 1 kilogram of water is 1 liter of water. In the English system, 1 quart is not 1 pound. In metric, 1 milliliter of water is 1 cubic centimeter, and 1 gram of water is 1 cubic centimeter. In the English system, 1 fluid ounce is not 1 cubic inch.

Scientists use the metric system all over the world. Whether the research is done in New York, Calcutta, Mexico City, Moscow, or Peking, the units in the report are in meters and grams.



Even if most of the rest of the world uses the metric system, should we?

47. Suppose all of the industrial countries of the world have one standard and the U.S. has a different one. Where does this leave the U.S. when it comes to international trade?

One big argument is that the U.S. loses a billion dollars a year in foreign trade because no one wants our foolish feet and inches. Some of the smart money is betting that we will switch. One of the few industrial countries that was not metric was Great Britain. They are now converting to metric.

Whether you use the metric system or not, standards are important.

48. When you go to buy a replacement part for your vacuum cleaner, why will the part fit?

49. When a scientist does an experiment, why should he use standard units of measurement?

CONCEPT SUMMARY.

Investigation 8

Will You Be a Dropout?

Here is a table showing what percentage of people are married or single. It is broken down by sex and age groups. Can you use it to decide when you are most likely to be a married person?

TABLE NO. 1

MARITAL STATUS OF THE POPULATION BY SEX AND AGE

(percent of persons 14 years and over)

Sex and Age	Percent Distribution			
	Single	Married	Widowed	Divorced
MALE	26.7	67.9	3.2	2.1
14 to 19 years	97.5	2.5	-	-
20 to 24 years	53.8	45.2	-	1.0
25 to 29 years	15.2	82.9	0.1	1.8
30 to 34 years	11.7	85.5	0.2	2.6
35 to 44 years	8.0	88.9	0.4	2.8
45 to 54 years	5.9	89.1	1.8	3.3
55 to 64 years	7.3	85.2	4.4	3.0
65 to 74 years	6.6	80.1	10.8	2.5
75 and over	5.8	58.9	32.9	2.3
FEMALE	20.9	63.2	12.6	3.2
14 to 19 years	89.8	10.0	-	0.2
20 to 24 years	32.8	65.1	0.3	1.8
25 to 29 years	9.9	86.4	0.5	3.3
30 to 34 years	4.7	89.5	1.3	4.5
35 to 44 years	4.7	87.9	2.7	4.7
45 to 54 years	5.0	82.1	8.3	4.6
55 to 64 years	6.2	67.3	21.8	4.7
65 to 74 years	7.4	46.4	43.8	2.3
75 and over	7.1	19.9	72.0	1.1

Here is a table that tells you where some of the boys and girls are. Why might someone use this table?

Karen Robinson has a high school education and some on-the-job training. She can take information from a table and type it into a small computer. Could you take information from a table and understand it?

TABLE NO. 2
SEX RATIO IN SELECTED AREAS

Area	Men per 100 Women
Alaska	132
Utah	100
Washington, D.C.	88

Picture Courtesy of Friden, Inc., a division of The Singer Co.

Let us review what you have discovered:

a. Accurate observations are necessary to recognize problems.

b. Events in nature occur in a predictable way.

c. Predictions point the way to possible solutions to problems.

d. Experiments provide information that will support or reject predictions.

e. All experiments must have a control.

f. There should be standards of measurement.

g. Worldwide, the most-used set of measurement standards is the metric system.

In Investigation 6 you used lots of numbers to show table widths. Look back at that data sheet and note the large collection of numbers. What a mess! Experimental results should be expressed in numbers to be meaningful. They should be organized so they will not be misinterpreted.

A. MORE BOUNCE TO THE OUNCE

1. How do you arrange a set of disorganized numbers in a neat, simple, and understandable manner?

You will use the familiar collection of balls. You may have noticed that each ball bounced to a different height. If you were asked to buy a ball that bounces very high, what kind would you buy: a solid ball, a hollow ball, a light ball, a heavy ball, a large ball, a small ball?

2. What kind of a ball do you predict bounces the highest?

Get the balls and a meter stick. It takes two people to do this experiment accurately. One person should hold the meter stick and drop the ball. The other person should read how high the ball bounces and catch it. Before you begin, ask yourself some questions.

3. From what height will each ball be dropped?

4. How many times will you drop each ball? Why?

You will put the measurements you collect in a data table. Data tables are designed differently for different experiments. However, they all have certain things in common:

a. numbering in consecutive order

b. title

c. a rectangular frame, or box, enclosing the table

d. columns and rows

e. headings and subheadings, as needed, for the columns and rows

f. units of measurement specified in headings and subheadings

On your data sheet is a table appropriate for this experiment, but you do not have to use this table. Feel free to design a better one.

Now do the experiment and record your data in Table No. 3 on the data sheet.

5. What ball in your collection bounces the highest?

6. Did you predict correctly?

You did this experiment to become familiar with data tables. In the investigations to follow you will be given less and less help in making data tables. In time, you will make your own tables. When that happens, refer to this investigation if you need help.

B. DON'T GET FOOLED AGAIN

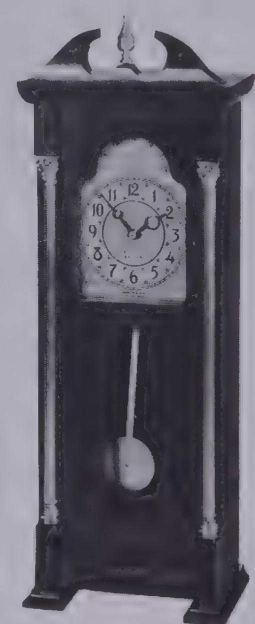
Far too often people make statements without adequate proof. Proof can be furnished in the form of data. The more data you collect, the better your proof.

In Investigation 5 you probably predicted that everyone was getting the same number of swings on the pendulum. But they weren't. You didn't have the data. Let's get the data.

You discovered that the length of the string affects the number of swings. But which swings faster: a long pendulum or a short pendulum?

7. What do you predict?

To test your prediction you need a meter stick, a long piece of string, a piece of tape, a paper-clip hook, and a washer.



United Metal Goods Mfg. Co., Inc.

United Metal Goods Mfg. Co., Inc.

Do not rush into experiments. Before you start, ask yourself what lengths of string you will use, and how many times you will swing the pendulum for each length.

Do the experiment and fill in Table 4 on the data sheet.

8. How do the data compare with your prediction?

C. DON'T BE A DROPOUT

Here are some more examples of data tables.

TABLE NO. 5
WORLD SERIES MONEY

(Each player's share in first four games)

		Winning		Losing	
Year	Games	Players	Share	Players	Share
1948	6	Indians	$6,772	Braves	$4,570
1949	5	Yankees	5,665	Dodgers	4,227
1950	4	Yankees	5,737	Phillies	4,801
1951	6	Yankees	6,446	Giants	4,951
1952	7	Yankees	6,026	Dodgers	4,200
1953	6	Yankees	8,280	Dodgers	6,178
1954	4	Giants	11,147	Indians	6,712
1955	7	Dodgers	9,768	Yankees	5,598
1956	7	Yankees	8,714	Dodgers	6,934
1957	7	Braves	8,924	Yankees	5,606
1958	7	Yankees	8,759	Braves	5,896
1959	6	Dodgers	11,231	White Sox	7,275
1960	7	Pirates	8,417	Yankees	5,214
1961	5	Yankees	7,389	Reds	5,356
1962	7	Yankees	9,882	Giants	7,291
1963	4	Dodgers	12,794	Yankees	7,874
1964	7	Cardinals	8,622	Yankees	5,309
1965	7	Dodgers	10,297	Twins	6,634
1966	4	Orioles	11,683	Dodgers	8,189
1967	7	Cardinals	8,314	Red Sox	5,115
1968	7	Tigers	10,936	Cardinals	7,078
1969	5	Mets	18,338	Orioles	14,904

TABLE NO. 6
THE TOP 10 BREWERS

(Ranked by barrels—1968 Estimates)

1. Anheuser-Busch	18,350,000
2. Schlitz	11,600,000
3. Pabst	10,750,000
4. Falstaff	6,600,000
5. Coors	5,303,000
6. Schaefer	5,050,000
7. Carling	5,000,000
8. Miller	4,900,000
9. Hamm	4,311,500
10. Associated	4,000,000

TABLE NO. 7
NUMBER OF PERSONS REACHING AGE 18 IN U.S.A.

1949	2,161,000	1960	2,940,000
1950	2,087,000	1961	2,761,000
1951	2,065,000	1962	2,740,000
1952	2,152,000	1963	2,750,000
1953	2,167,000	1964	3,781,000
1954	2,170,000	1965	3,506,000
1955	2,261,000	1966	3,512,000
1956	2,303,000	1967	3,491,000
1957	2,299,000	1968	3,619,000
1958	2,402,000	1969	3,688,000
1959	2,572,000		

Aigner from Monkmeyer Press Photo Service

9. What was a Yankee player's best winning year?

10. What kind of beer sells just about twice as many barrels per year as Schaefer's?

11. In what year were about a million more babies born than in the previous year?

With these examples to help you, you should have no trouble making a data table from written information. Here is the information.

(1) If you didn't finish 8 years of school, you are probably averaging around \$86 a week.

(2) If you finished just 8 years, you are likely to be making about \$117 a week.

(3) Getting 1 to 3 years of high school is worth about \$138 a week.

(4) Finishing high school raises you to around \$158 a week.

(5) Two or 3 years of college lets you average about \$178 a week.

(6) Making it all the way through college takes you to around \$229 a week.

In percent of increase over the person who didn't finish the eighth grade, the figures are:

(2) Finishing eighth grade is a 36% boost.

(3) The first few years of high school up the ante by 60%.

(4) Finishing high school brings in 84% more.

(5) Going part way through college makes it 107% more.

(6) Getting through college runs up a 166% score.

Make the above information into Table 8 on your data sheet.

12. What message comes through loud and clear from Table 8?

13. Why are data tables of help to a scientist?

CONCEPT SUMMARY. (Note: The concept summary is not about balls, pendulums, or income and education.)

Investigation 9

40,000 Jobs Lost per Week

If one of your teachers put test results on the board like those below, it would take a while to decide how you did.

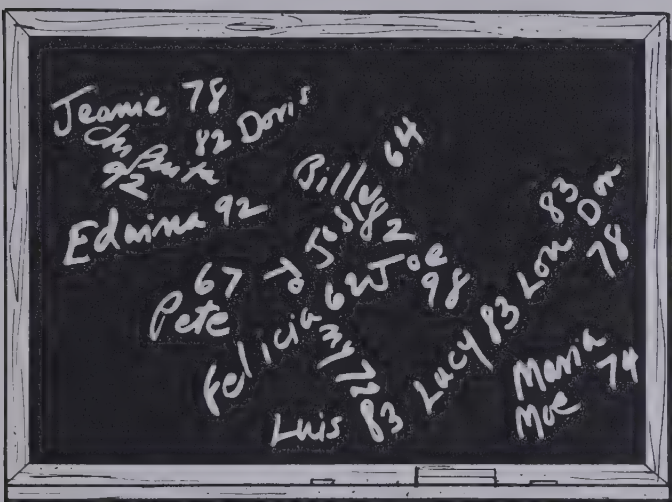


TABLE NO. 1

DOLLAR SALES OF PHONOGRAPH RECORDS IN U.S.A.

Year	Millions of Dollars	Year	Millions of Dollars
1960	480	1965	630
1961	513	1966	700
1962	573	1967	780
1963	530	1968	860
1964	579	1969	1,200

In the last investigation you found a better way to organize information. Put it in a table like Table No. 1.

There are lots of numbers and they are in order. Your eye can go up and down the columns easily. Are tables the final word? You are on to us. You think something more is coming. You're right.

A. DRAW ME A PICTURE

1. What can we use to make data easier and simpler to understand?

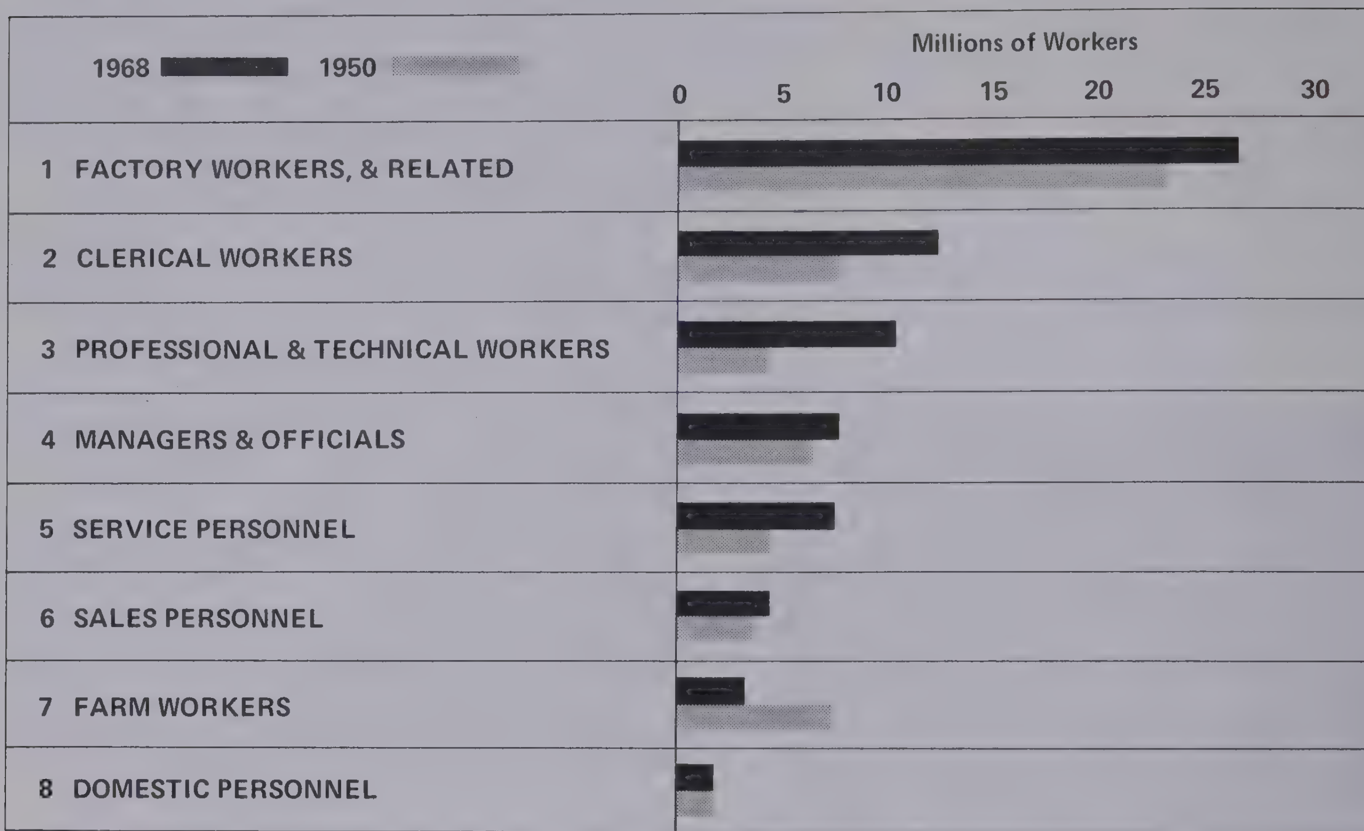
A good picture can deliver a real message. It can hit you right in the soul. A scientist uses pictures too. He calls his pictures *graphs.*

A graph is a pictorial way of showing data. It makes it easier to see data. If it is a good graph, you will get the message immediately.

Look at Graphs No. 1 and 2. They don't look alike, but each does its job. They make data easier to understand. There are some things they have in common.

GRAPH NO. 1

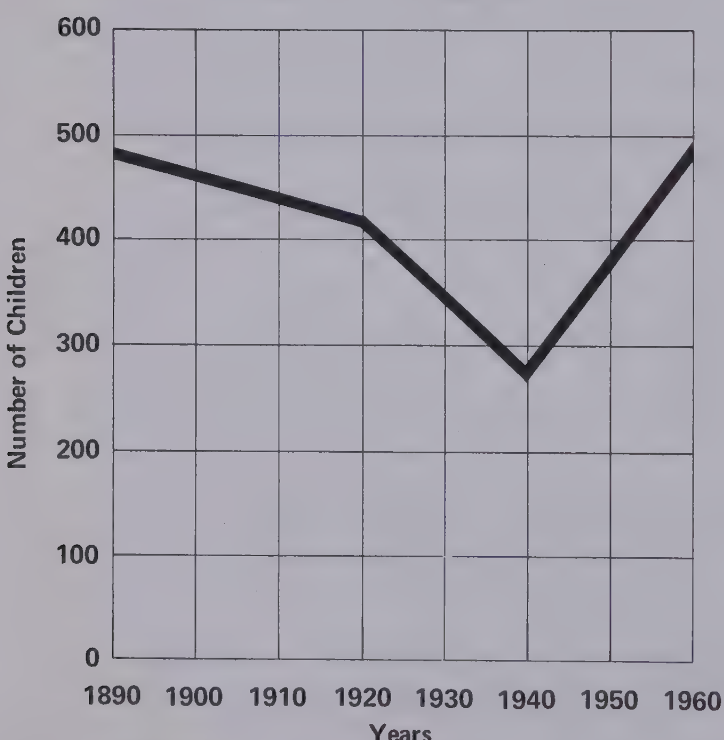
COMPARISON OF WORKERS IN 8 JOB GROUPS—1950 and 1968



GRAPH NO. 2

CHILDREN UNDER 5 YEARS OLD PER 1,000 WOMEN

(Women 15 to 49 years old)



2. What is the first thing that tells what the graph is all about?

3. What do you see along the bottom or top and up the sides of these graphs?

4. When there are numbers, how are they spaced along the edges of the graphs?

Graph No. 1, about employment, is a bar graph. Actually, it is a double bar graph, because there are 2 bars for each of the 8 headings. On some bar graphs the bars go up from the bottom.

This graph shows how many workers were employed in each of 8 major job groups in 1968 and also in 1950. Lots can be learned from such a graph.

5. What type of worker showed the greatest increase from 1950 to 1968?

6. Why didn't you have to stop and figure out the exact numbers to get the answer to question 5?

Graph No. 2, about children, is a line graph.

7. Around when were the least number of children being born per thousand women?

8. Why didn't you have to know exactly how many children there were to answer question 7?

Now make a bar graph of your own. The bottom and left edges of the graph are called its axes. Use what you have learned about labeling them. Use the totals of record sales (Table 1) as your subject for this graph.

Now go ahead and make Graph No. 3 on your data sheet.

9. Of the years shown, what was the biggest year for records?

10. What was the year with the least sales?

11. What seems to be an average year?

12. How many more dollars worth of records were sold in the biggest year than in the worst year shown?

13. Does the graph suggest that record sales are going up, down, or staying about even?

14. In what three-year period did the greatest change, up or down occur?

B. IT SHOWS MORE THAN IT TELLS

Let's try another graph, this time a line graph. Use the data in Table No. 2.

15. How many points will you mark?

16. What will you do after marking the points?

Now go to it and make Graph No. 4 on your data sheet.

Sometimes a graph even shows more than the data tells.

TABLE NO. 2

THE GROWTH IN WORLD POPULATION

(past and projected)

Year	Billions of People
1900	1.5
1925	1.9
1950	2.5
1975	3.9
2000	6.3

17. For instance, consult your Graph No. 4. How many people were there in 1960?

18. How many people do you estimate there will be in 2025?

So you see, a graph can give you more information than you collected. Graphs can be very helpful. Pollsters use them to predict the results of elections. Businessmen use them to predict sales possibilities. Sports writers use them; television producers use them. Scientists couldn't do without them. There's a graph for everyone.

C. WILL YOU HAVE A JOB TOMORROW?

Because of scientific and technological advances, 40,000 jobs are being cut out each week. This is 2 million jobs per year. Most of the jobs that are eliminated require little education or training. But when a machine eliminates such a job, it often creates a job that requires more training. Each year, more than one and a half million new jobs of this kind are developed. Make Graph No. 5 on your data sheet from the information in Table No. 3. Use a double bar graph to compare New York City with the U.S.

TABLE NO. 3

TYPES OF JOBS IN THE UNITED STATES AND NEW YORK CITY

(percent of all jobs)

Type of Job	United States, %	New York City, %
White collar	47.5	55
Blue collar	40	31
Service	12.5	14

19. What kinds of jobs are more common in New York City?

20. What should a person who is living in the city do to prepare himself for a job?

21. Why are graphs important?

CONCEPT SUMMARY. (It has nothing to do with population or unemployment.)

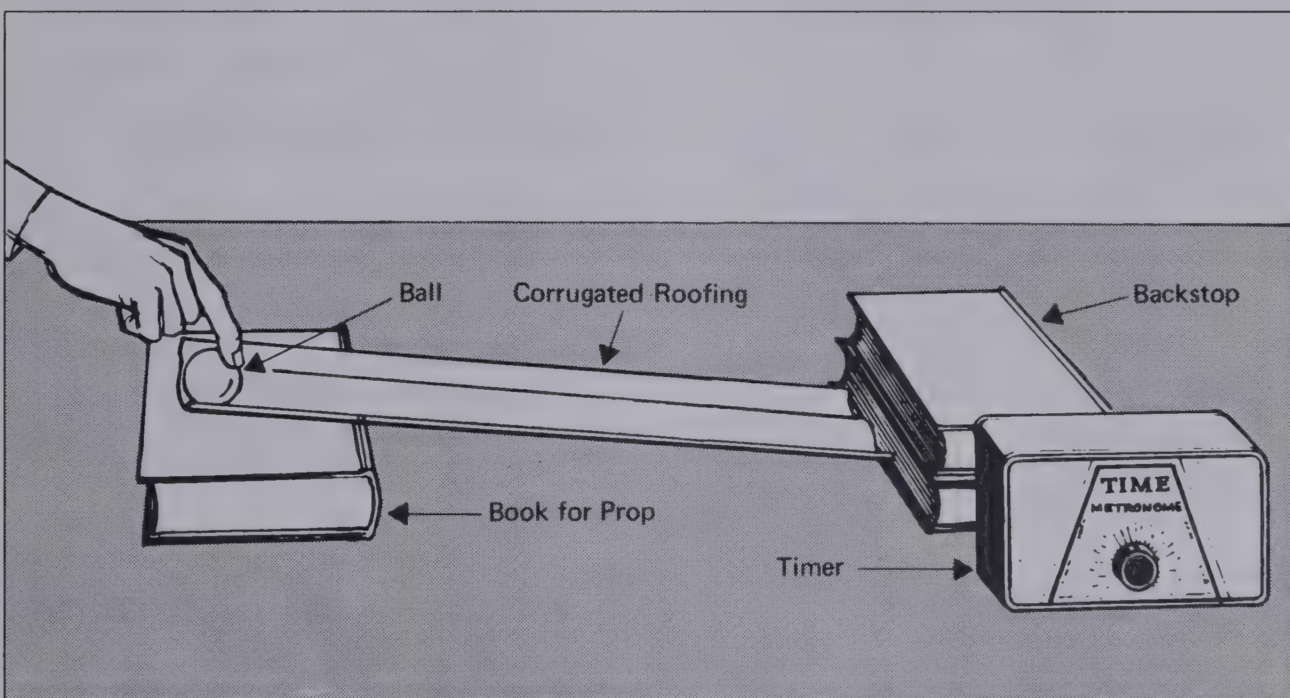
Investigation 10

Don't Stop Me, Man–I'm Really Moving

You have caught on to the spirit of science. You've learned how to run a controlled experiment. You've discovered that science is finding answers and solving problems on your own.

A. KEEP 'EM ROLLIN'

In Investigation 8 you found which of your seven white balls bounces the highest. Does a ball that bounces the highest also roll down a hill the fastest? Let's try it.



Get the seven white balls and a length of corrugated roofing to use as a runway. Use a book to raise one end of the runway. Place another book at the lower end to stop the ball. You also need a timing device. Your data will be the number of clicks on the timer it takes for a ball to roll down the runway.

Set the timer to a fast beat. Take your time and do the investigation well. You are on your own. Write up the experiment fully on the data sheet. Use everything you've learned from the past nine investigations.

Problem: What are you trying to find out?

Prediction: What do you think the answer will be?

Equipment: List everything you will be using.

Procedure: How will you do the experiment?

Results: Make a data table and a bar graph of the data you obtained. Use only the averages for the graph.

Conclusion: What do the data tell you? Did you predict correctly? The last thing you did was to draw a conclusion from your experiment.

1. What must all conclusions be based on?

B. THE TWO FACES OF SCIENCE

What you have just done is the important final act of scientific research. You have written what a scientist calls a *paper.* It's a complete description of one particular experiment. These papers are published in magazines called *journals.* Almost everything that has ever been discovered in science can be found in journals. They give the products—the conclusions—of science. The products of science are not airplanes, pills, and computers. Information is the product of science.

Published scientific information nowadays almost doubles every ten years. It would take one man 460 years just to read one year's output of scientific journals. But every page of this published information came from some scientist doing an experiment in a laboratory, somewhere.

Briefly explain the two statements below.

2. Science is an activity.

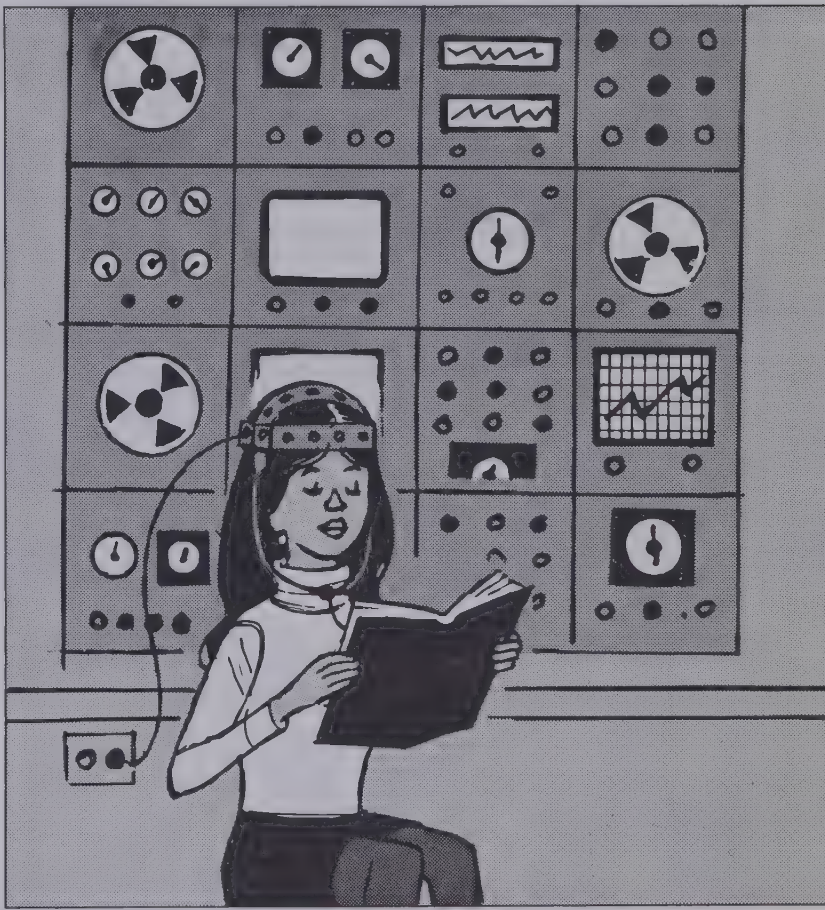
3. Science yields an organized body of information.

CONCEPT SUMMARY. (Tell what you have learned about how conclusions in science are made.)

Investigation 11

Science Is Where the Action Is!

Scientific discoveries have already changed your environment and your life greatly. The most striking change may be in man himself. Before long we may be able to control the body's functions, including those of the brain. No matter how you look at it, you are—and you will be—living in an age of science.



You've discovered a lot about the way scientists work as you've gone through Idea 1.

a. Accurate observations are necessary to recognize problems.

b. Events in nature occur in a predictable way.

c. Predictions point the way to possible solutions to problems.

d. Experiments provide information that will support or reject predictions.

e. All experiments must have a control.

f. There should be standards of measurement.

g. Experimental results should be expressed in numbers to be meaningful.

h. Tables simplify the recording of data.

i. Graphs simplify the interpreting of data.

j. Conclusions must be based on the evidence collected.

A. A BOY SCOUT WOULD KNOW HOW

Situations in everyday life are often like those in science. A good cook does not use a recipe. He experiments to find the right flavor. A scientist is no different. He knows that some of the ground rules for solving scientific problems are:

a. State the Problem: What do I want to know?

b. Make a Prediction: What do I think the answer will be?

c. Perform an Experiment: How do I tell what the answer will be?

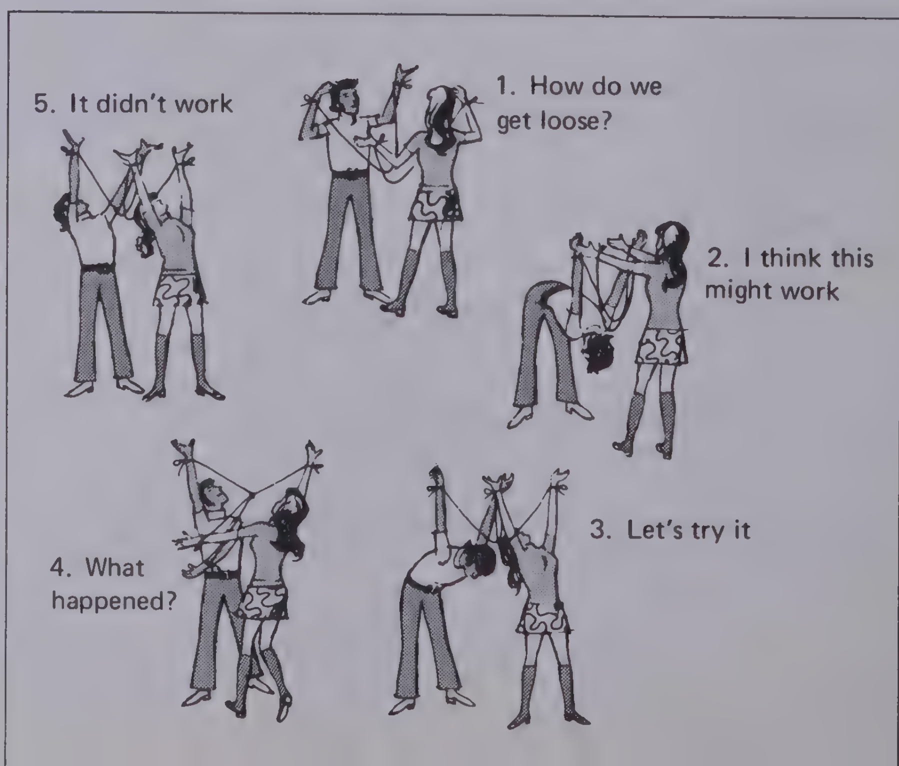
d. Organize the Data: What happened when I tested my prediction?

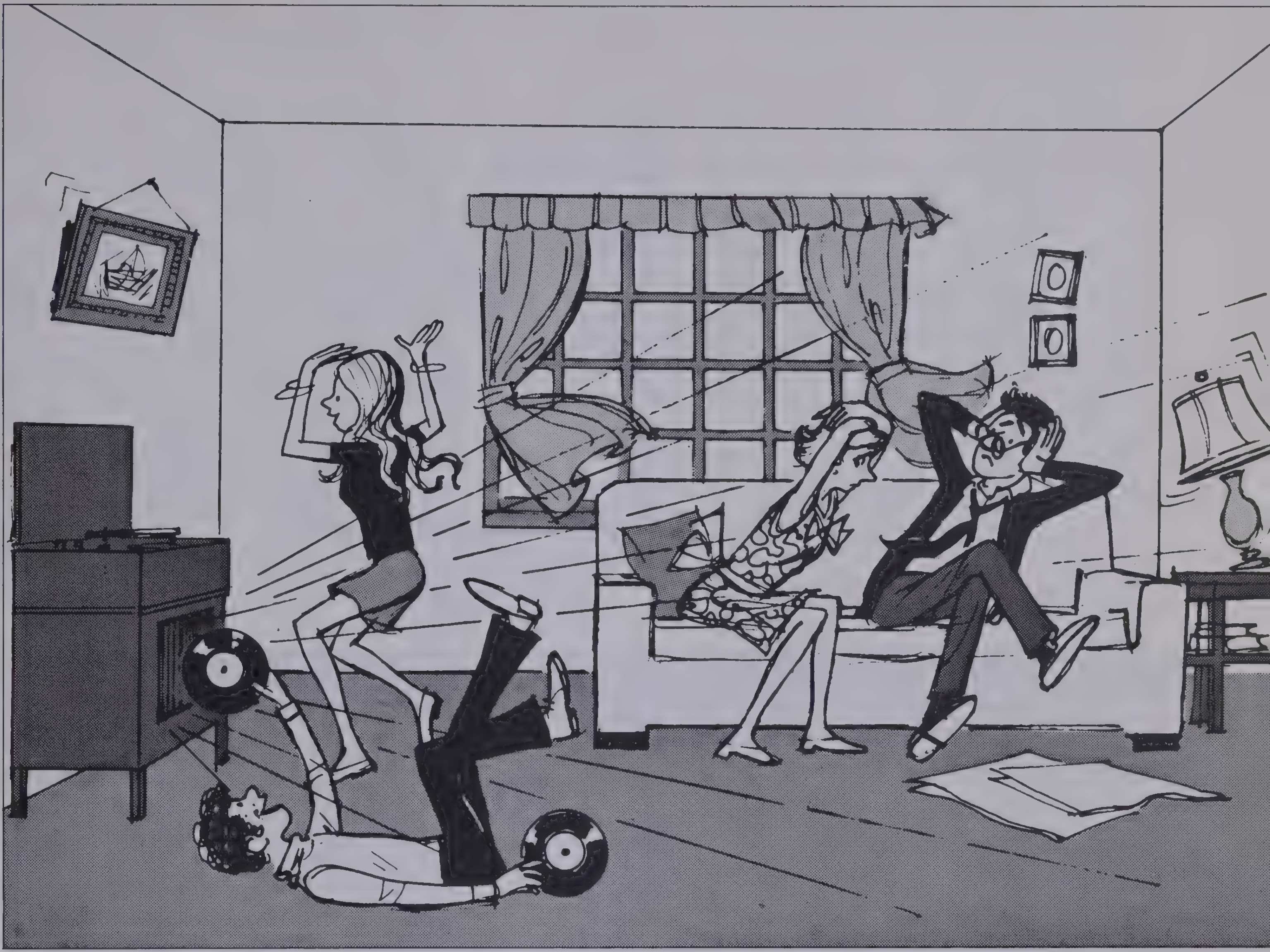
e. Draw a Conclusion: What do the results of the experiment mean?

The same method is used in making daily decisions. You can even use it at parties. Have you ever played the following game?

A piece of string is tied to both wrists of one person. Another piece of string is tied to one wrist of a second person, passed behind the loop of string tied to the first person, and then tied to the second wrist of the second person. The problem is to free the two persons without untying or breaking the string. Go ahead and try it.

What process of science is represented by each of the five little pictures? Fill in the correct words on lines 1 through 5 on the data sheet.





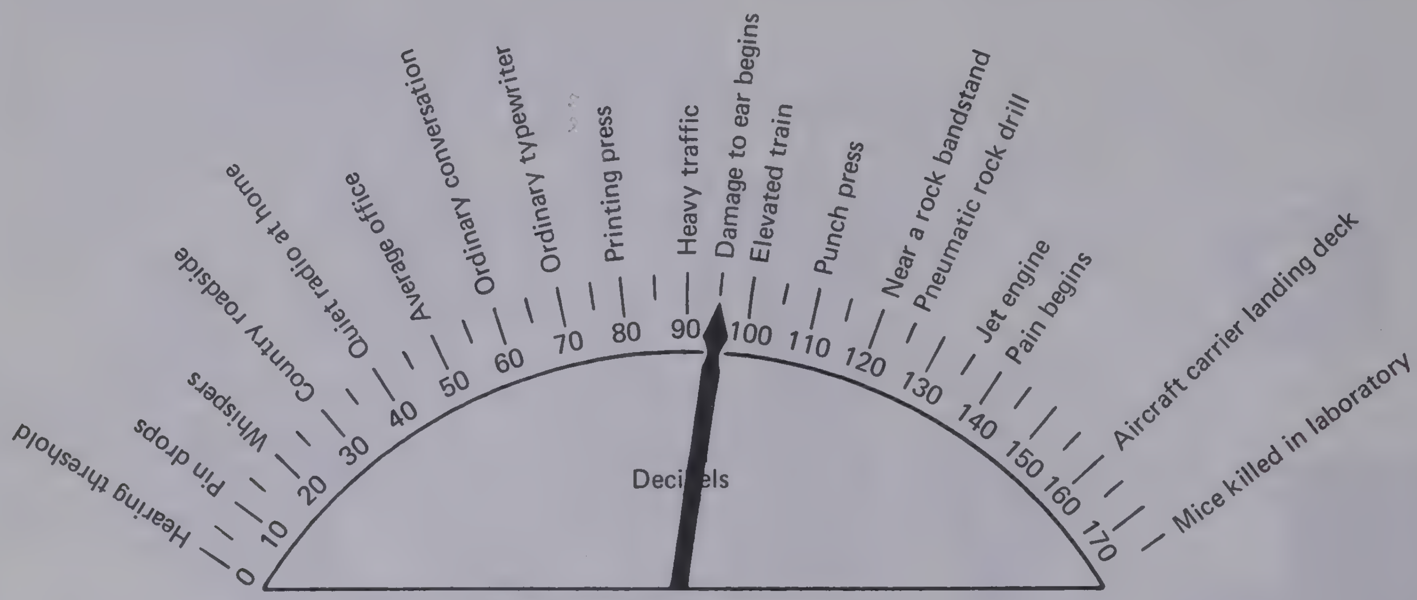
B. YOU CAN'T HEAR THE BEAT?

Science does not end when a problem is successfully solved. New problems arise. Solved problems lead to further problems. Science is a continual testing of our natural world. Let's use the scientific way of thinking to discuss a current problem.

Parents keep telling their kids to turn down that record player, TV, or radio. The music lovers answer (if they can hear the complaint) that you don't *feel* the music if it isn't loud enough. This may be the beginning of an argument.

It is also the beginning of a problem. Is the loud sound of a great rock combo just annoying to some people, or is it a real danger? Should you turn down the volume or keep rattling the windows?

What are the facts?



Familiar sounds vary in intensity

First listen to one speaker. Then add a second speaker at the same volume. Your ear does not hear them twice as loud, just a little louder. To make a unit that would fit the way your ear hears, scientists developed a unit called the *decibel.* The diagram above shows how many decibels are recorded for sounds you often hear.

6. What does the table say about sound at 95 decibels?

7. If mice can be killed by noise, what effect might it have on people?

Workers in noisy industries gradually lose hearing until they can't hear ordinary whispers. When a scientist tested the players in the Marine band, he found half of them had damaged hearing. Doctors say that anything over 95 decibels can cause permanent hearing loss.

8. What do you think the solution of the problem is? Give your reasons.

So we see that the ground rules of science can also be used in your daily life. All too often people make snap judgments, draw conclusions without any valid test or comparison, and just get mad without any good reason. Science can help all human relationships, not just noise in the home. Science means thinking objectively about the facts. Problems can be solved when our actions are based on facts, instead of on hate, greed, or fear.

9. What happens when excited people force themselves to sit down and look at the facts?

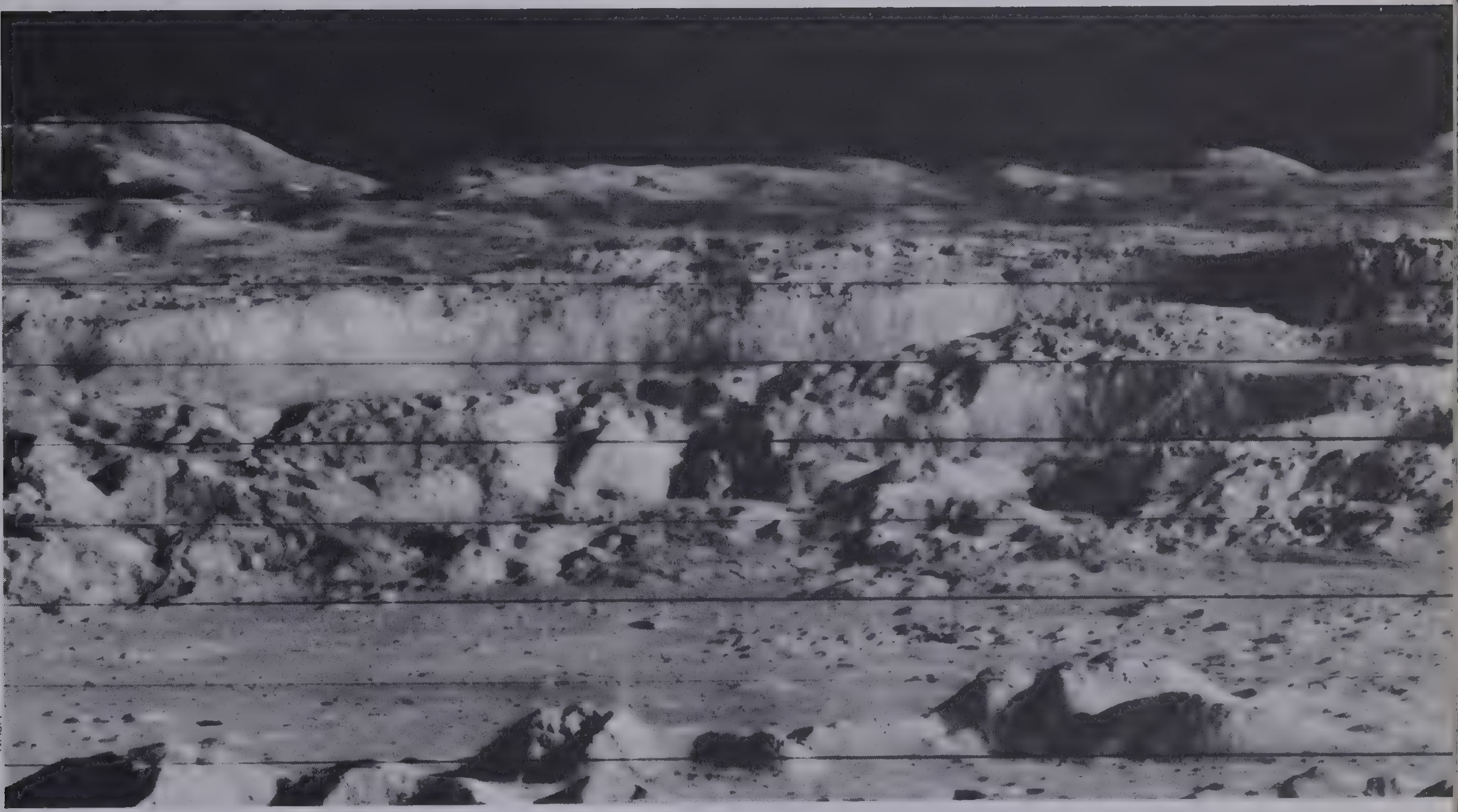
CONCEPT SUMMARY. (Tell how science can be related to everyday problems.)

Idea 2
Matter

Investigation 1

That's About the Size of It

Is the moon made of green cheese? Are an ocean liner and a robin the same substance?



NASA

Landscape on the Moon

If you ask almost anyone what everything is made of, he may say *atoms.* We are going to assume that you have heard about atoms at one time or another in your life. Atoms are mentioned constantly in newspapers, magazines, and on television. Everybody has heard of an atomic bomb and atomic energy. Yet no one has ever seen an atom!

So, what is everything made of? Maybe each object is made of different things. Or maybe all things have something in common. In fact, when you speak of "everything," just what are you talking about?

A. ELEPHANTS AND CHOW MEIN

You will be given a collection of different objects. You are to describe them. You learned a word in Idea 1: *properties.* When you describe the properties of an object, you tell what it is like in many different ways. Do not look at the shapes of the objects. Look for properties of the substances of which the objects are made. Look for things like hardness, softness, or bounciness.

1. List each object and its properties.

Tom King from Black Star

2. Read over the properties you just listed. Can you tell what *very general* properties the objects all have in common? There are only two.

3. Would an elephant have the same two properties?

4. How about a light bulb?

5. Would the same two properties apply to a piece of paper, bacteria, a hub cap, water, air, a calendar, a football, cheesecake, a blackboard, and a pound of chicken chow mein?

6. As a matter of fact, does just about everything in the world have these same two properties?

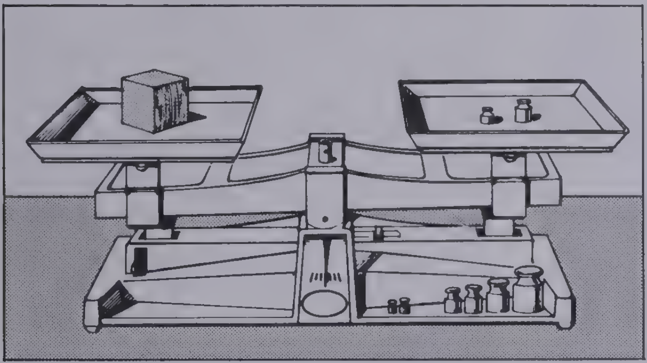
7. Name one or two things (there aren't many) that do not have these two properties.

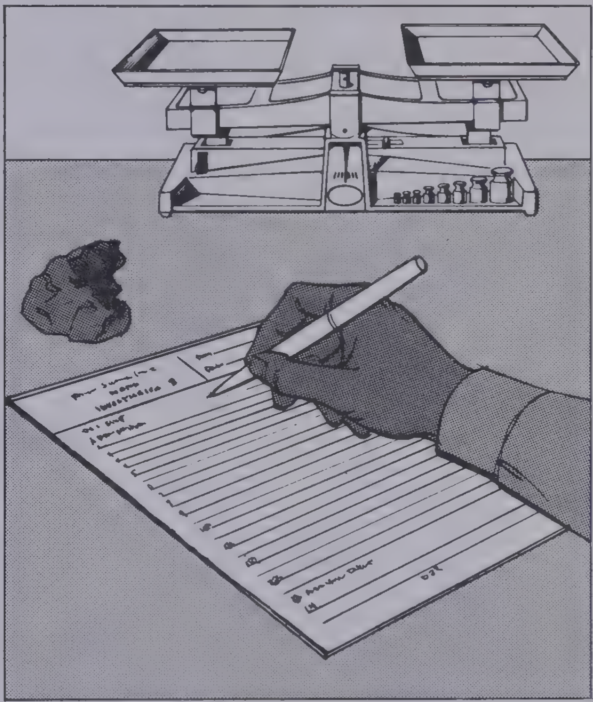
8. Except for the few things you may have thought of in number 7, everything in the world has these two basic properties. What name do scientists give to everything having these two properties?

Brassai from Rapho-Guillumette Pictures

B. IT'S TOO LATE TO DIET NOW

You just predicted that all matter has weight. Let's test it.

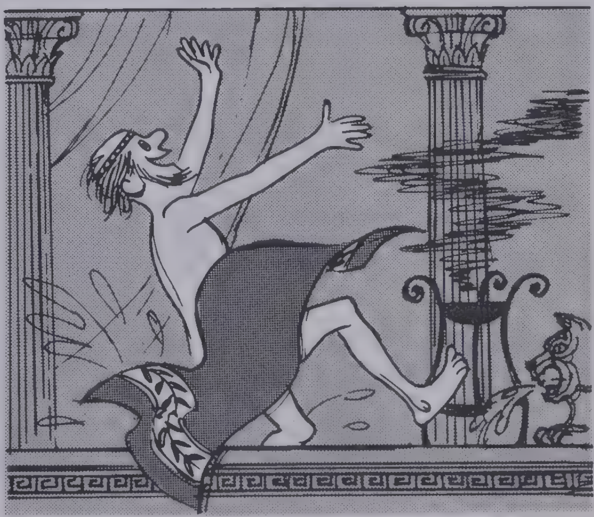




9. Weigh the collection of objects you described. List the objects and their weights. Do not forget to indicate the unit of weight.

10. What other property is needed to show that these are made of matter?

C. ARCHIMEDES IS PROUD OF YOU



You also predicted that all matter takes up space. If it takes up space, it has volume.

But how do you *know* it has volume? Archimedes was an ancient Greek wise man who hit on the answer one day as he was taking his bath.

If you trip over a cat you know it takes up space. What if you want to know how

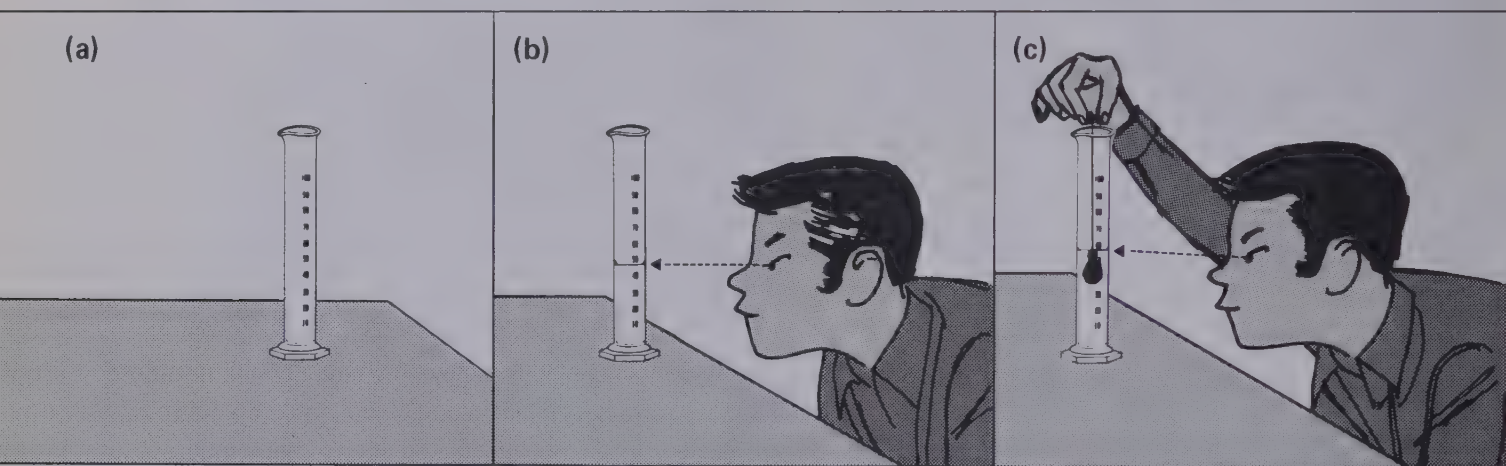
much? Cats don't always cooperate, so try something simple, like a brick or a cube. If the object has a regular rectangular shape you can measure its length, width, and height. Calculate the volume by multiplying them together. That takes care of the easy problems; now what about a piece of rock or a fishing sinker?

11. If you take an object like a rock and gently drop it into a container filled with water, what will happen to the level of the water? Why?

Water, like most liquids, is measured in a graduated cylinder. If you want to know the exact volume of an object, using the previous method, then you will need a graduated cylinder.

12. Examine a graduated cylinder. What volume does each space on your graduated cylinder represent?

Add some water to your graduate. Place it on a flat surface. Bend down until your eye is level with the water. You will notice that it curves up slightly. Make the reading at the lowest point of the curve. Lower an object into the water with a thread until it is completely below the water. Then read the volume again. (If the object floats, push it below the water with a wire before reading the volume again.)



13. What is the volume of the object?

14. How did you find it?

15. Find the volumes of all the objects you have weighed. List the objects and their volumes. Do not forget to indicate the unit of volume.

16. All of these objects have volume. What are they made of?

CONCEPT SUMMARY. (State what you have discovered concerning just about everything in the world.)

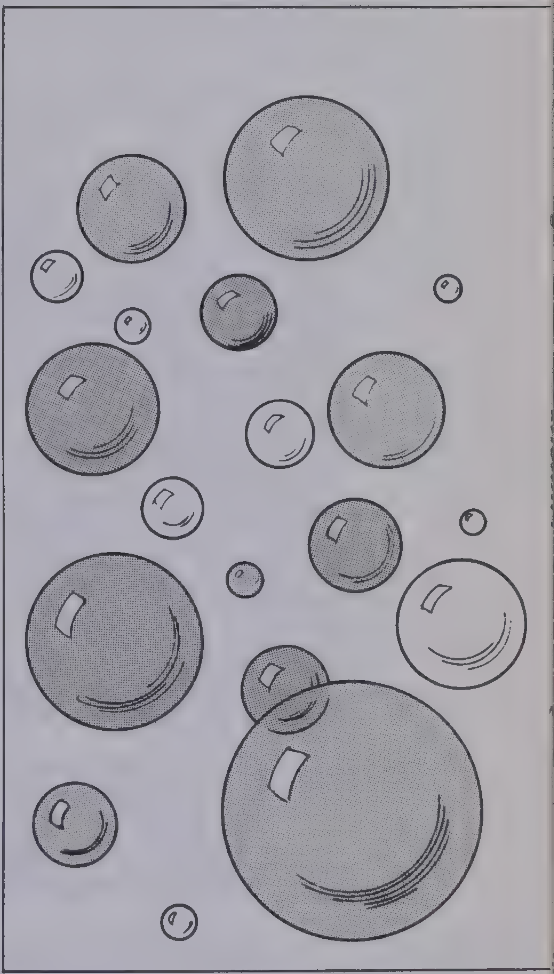
Investigation 2

Just How Much Is in that Bag?

In the last investigation you learned that almost everything in the world weighs something and has volume. If it has the properties of volume and weight, then we say it is some kind of *matter.* Matter can be anything from Mt. Everest to a koala bear to a soap bubble.

Copyright: The Mount Everest Foundation

Australian News and Information Bureau



However, even when you can see matter and feel its weight, matter can fool you. It's like the ad: "It may look just like tomato juice, but it sure doesn't taste like tomato juice." You have to be alert in this world.

A. LET'S START OUT DRY

1. If someone gave you a quart of water and a quart of oil, would you say that both were the same size? Why?

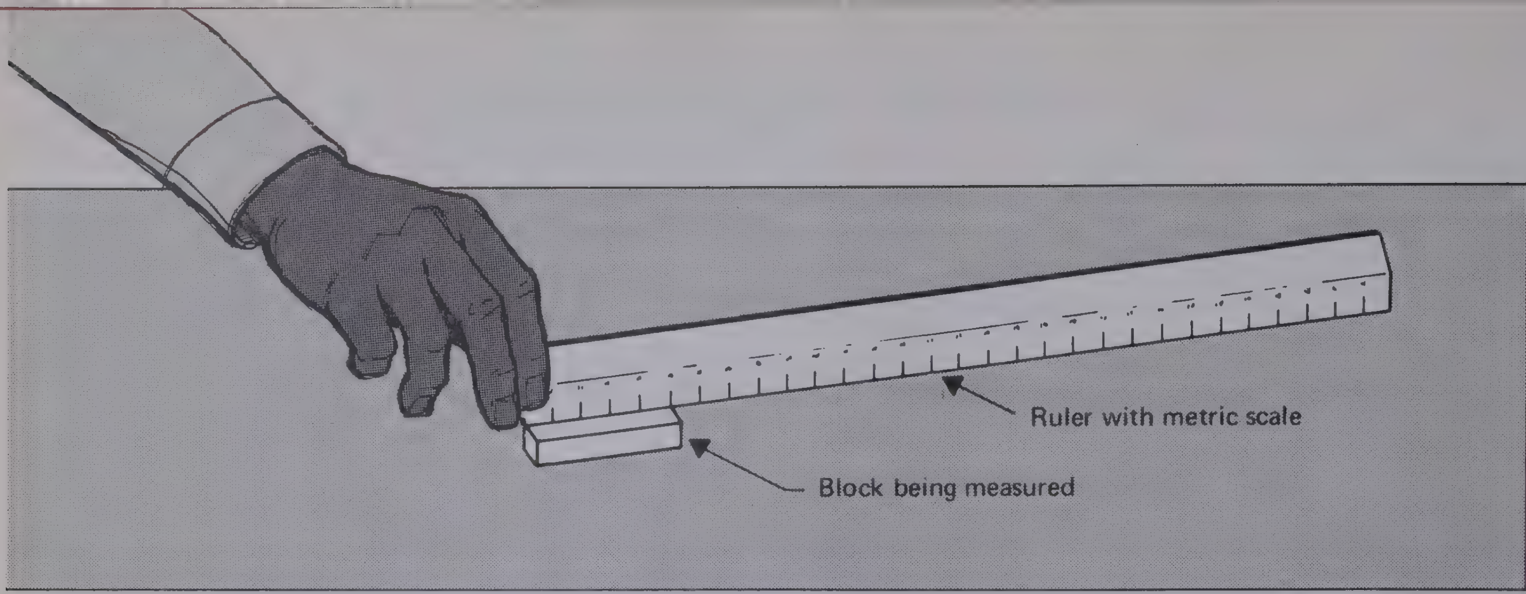
2. Would both quarts have the same weight? Explain your answer.

You will be given a set of blocks. They look about the same, but to be sure you will measure each block and find its volume.

3. What is the shape of the blocks? (Mention some common object it is like.)

4. To determine volume, you will have to measure and multiply three things. What are they?

5. If your measurements are in centimeters, what is the unit of volume? Hint: length is a *line,* area is a *square,* volume is a __?__



Find the volume of each block and record it in the second column of Table 1. Weigh each block and record its weight in column 3.

6. What can you say about the volumes of the different blocks?

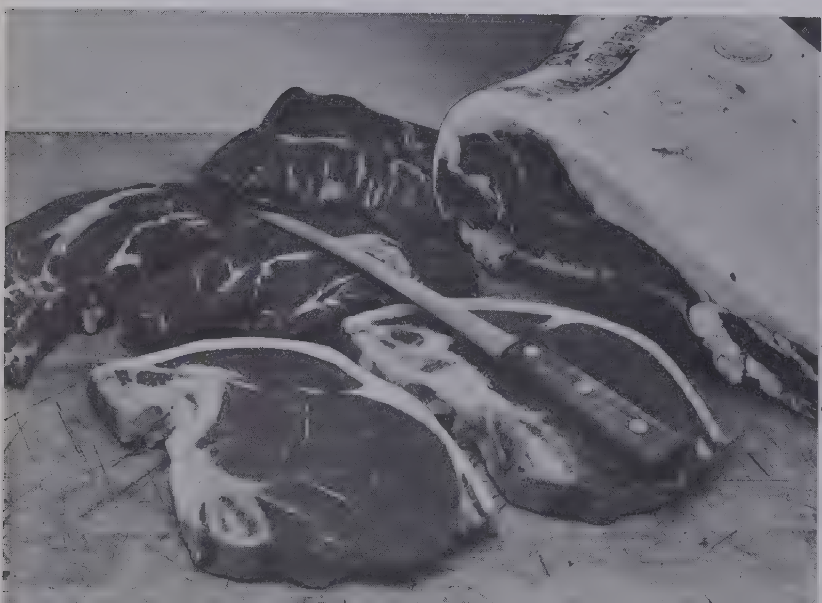
7. What can you say about the weights of the different blocks?

8. What can you say about the amount of matter packed into the different blocks when you compare one block with another?

9. You have discovered something about the relationship between weight and volume for different substances. What is it?

There is a property that tells us how much matter is in a volume of substance. What is this property called?

If you know that, per pound, rice is 29¢ and sirloin steak is \$2.00, you know about what you can have for dinner. And if a scientist knows that ether is 0.7 grams per cubic centimeter, and mercury is 13.6 g per cc, he knows an important difference about them.



Courtesy of Bohack–Packer's Supermarkets, Brooklyn, N. Y.

In both cases people want to know how much of something there is *per 1 unit* of something else. Rice is 29¢ *per 1 pound* of weight; mercury is 13.6 g *per 1 cc* of volume. This is its *density.* Both the prices and the densities of things are ways of comparing how much you get (or how much you give) of something for *1 unit* of the substance. The comparison is also called the *ratio* of one thing to another.

To compare the weight of an object to its volume, you simply divide the weight by the volume:

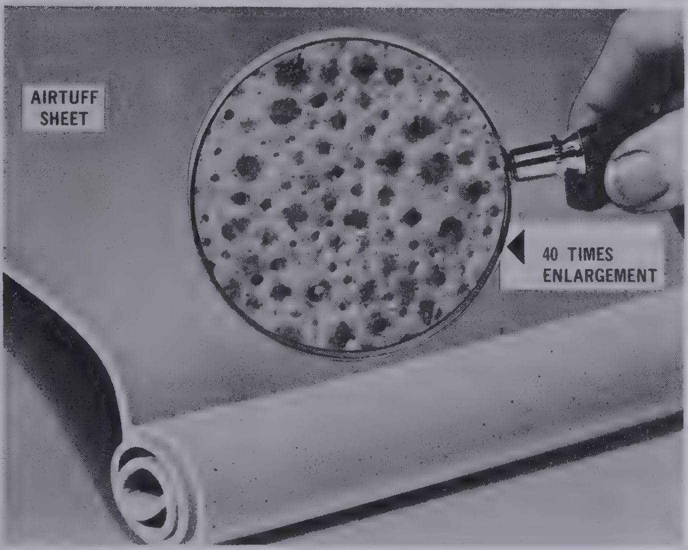
$$\begin{array}{r l} & \text{DENSITY} \\ \text{VOLUME} \,\big) & \overline{\text{WEIGHT}} \end{array}$$

10. What is the unit of density? Since it considers both weight and volume, both units will be in the answer. It will tell the weight in grams (g) of *one* cubic centimeter (cc) of a substance. If weight is in grams and volume is in cubic centimeters, we will call this unit "grams per_?_"

Determine the density of each block and record it in column 4 of the table.

11. Which block is the densest?

12. Can you tell the density of a substance just by looking at it? Explain.



Crown Rubber Co.

Foam Rubber


Federal Reserve Bank of New York

Gold Bricks

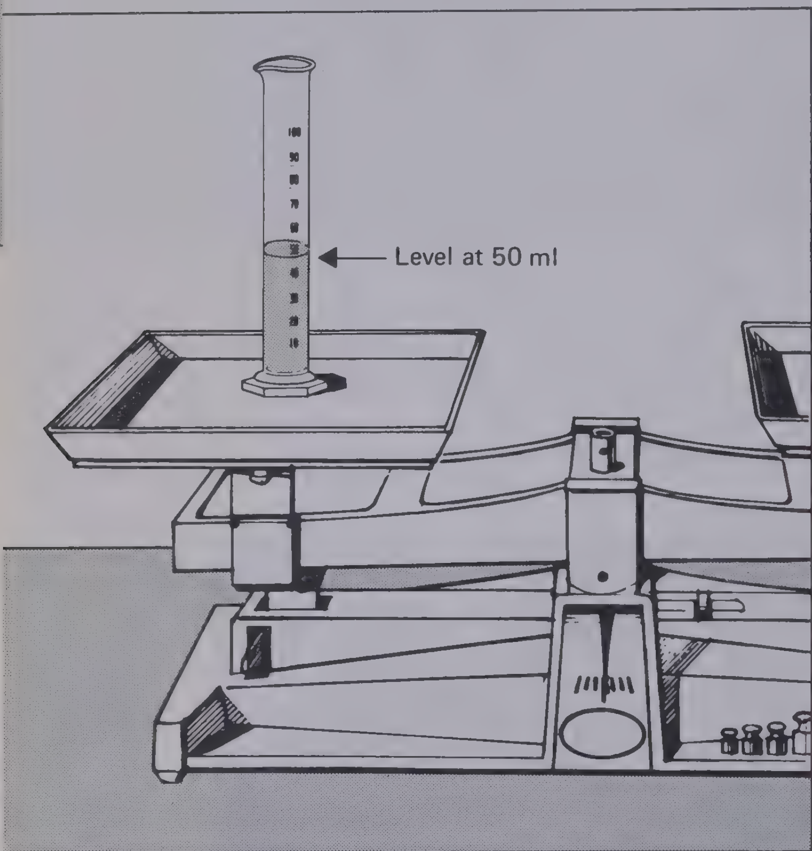
B. LET'S TRY IT WET

You remember from a previous investigation that metric units are related. For instance, one gram of water fills a tiny cube that holds one milliliter and measures one cubic centimeter in volume. Or, 1 g = 1 ml = 1 cc. Does this hold true for other liquids besides water?

To determine the density of a liquid, you will follow the same logic as you did for the solid blocks: find out the liquid's volume and weight, and divide the weight (g) by the volume (cc).

To weigh a liquid, start with the weight of its container. Weigh an empty graduate. Record its weight in the second column of Table 2.

You will be given a set of liquids. Very accurately, measure out 50 ml of the first liquid. Don't forget to set the graduate on a flat surface; bend over until your eye is level with the top of the liquid; and read the lowest point of the curve.



Weigh the liquid and the graduated cylinder together and record the result in column 3 of Table 2.

Pour the liquid back into the original container. Rinse and dry the graduated cylinder.

Repeat the procedure for all the liquids in your set.

Determine the weight of each liquid and record it in column 4 of Table 2. Record the volume (50 cc) in the fifth column of the table. Calculate the density of each liquid and record it in column 6 of the table. Do it this way:

$$\text{VOLUME} \overline{\big)\ \text{WEIGHT}}^{\ \text{DENSITY}}$$

13. All the liquids have the same volume but not the same weight. Which liquid is the densest?

14. What reason can you give for one liquid being denser than another?

C. IN CONCLUSION

15. Let's suppose you didn't know what a substance was. If you know its density, would this help identify the substance? Explain.

16. Therefore, why was it important for scientists to develop accurate methods of measurement to study matter?

CONCEPT SUMMARY. (Tell what you have learned about the property that measures how tightly matter is packed.)

Investigation 3

Time for a Thaw

Solids and liquids have weight, volume, and density. They also have color, texture, hardness, viscosity, and solubility, to name a few more properties. These properties may be used to tell different kinds of matter apart.

There is a complication. Do the properties of solids always apply to liquids and vice versa? Is hardness the same for a solid and a liquid? Do a solid and a liquid of the same volume have the same weight?

A. ANY WAY YOU SLICE IT, IT'S STILL WATER

We have been assuming that you can tell a solid from a liquid. Perhaps we should stop for a moment to ask:

1. What is the difference between a solid and a liquid?

J. Allan Cash from Rapho Guillumette Pictures

Matter also exists in another form: gas.

2. What is the difference between a gas and a liquid?

3. Thus, what are the three forms or states of matter?

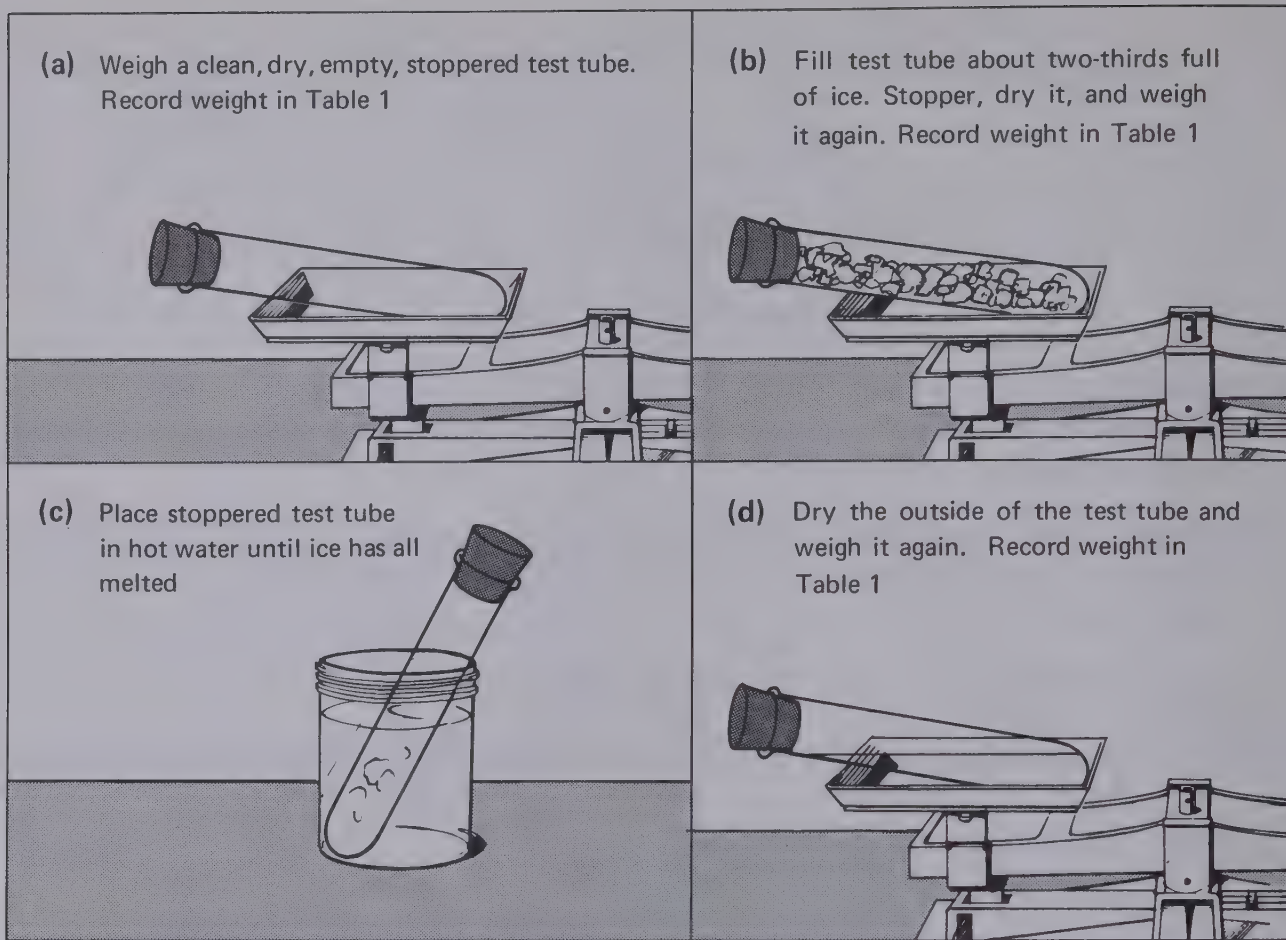
There is a big difference between a solid and a liquid. Their properties are different and the methods of measuring them are different. This leads to an important question: Does changing the form of a substance change its quantity?

To put it simply, will the water weigh as much after the ice melts?

4. What do you predict?

Official U.S. Coast Guard Photograph

Fred Lyon from Rapho-Guillumette



Empty the test tube, dry it, and repeat the entire procedure again for Trial 2. Complete Table 1 by finding the weight of the ice, the weight of the water, and any difference between them, for both trials.

5. What was the change in weight between the ice and the water that your team found?

Record the weight-change found by your team on the class data table on the board and in Table 2. Record the other teams' results in Table 2.

6. What was the average weight-change found by the entire class?

7. Did the amount of matter in the test tube change? Explain.

8. There are three states of matter. When you change from a solid to a liquid, what happens to the amount of matter?

CONCEPT SUMMARY. (Tell what you learned about the amount of matter—the weight—when it changes from one form to another.)

Investigation 4

A Rose by Any Other Name...

It may not smell like roses, but sulfur is a handy substance to use. It will help us investigate more deeply the question of whether a change of form causes a change in the amount of matter present.

Why are we so interested in this question? Until it is settled, we, as scientists, cannot be sure our measurements are useful; we don't know what matter might do next.

Another point is that we have only tested one substance. We can defend our own ideas about matter better with more data. Naturally we can't test everything, but if we test more than one substance we can be more confident that our predictions will apply to the rest of matter. Now let's look at sulfur.

Volcanic Lava Is Rich in Sulfur

A. SULFUR BALLOON

Weigh a balloon and an empty test tube together. Record the weight in Table 1.

Fill the test tube about one-sixth full of sulfur.

Fit the balloon over the tube and weigh it again. Write the weight in Table 1.

Gently heat the sulfur until it melts.

Examine the walls of the test tube near its mouth.

1. Describe what you see on the inside of the test tube.

2. What form did the sulfur take to make this happen?

Weigh everything again. Record the weight in Table 1.

After the sulfur has cooled and hardened, weigh it once more. Write the weight in Table 1.

Determine the weight of the original sulfur, the melted sulfur, and the cooled sulfur. Record all of the data in Table 1.

3. What change in weight does Table 1 show from powdered to melted sulfur, from powdered to hardened sulfur, and from melted to hardened sulfur?

Have one member of each team write on the board the largest weight-change that his team found. Record this data in Table 2.

B. WHAT'S LEFT?

4. What was the average weight-change found by the entire class?

5. Did the amount of matter in the test tube change? Explain.

6. How does this compare with what happened when you weighed the ice frozen and then melted?

There was evidence in the test tube that some of the sulfur formed a gas.

7. You started with powdered sulfur. If gas was formed, where did it come from and how?

8. What can you say about the quantity of matter as it changes form?

9. Do you think these results would apply to other kinds of matter? Explain.

CONCEPT SUMMARY. (Tell what you found about the amount of matter when it changes from one of the three forms to another.)

PHYSICAL SCIENCE Idea 2 Matter

Investigation 5

Somehow It's Not the Same

By the time scientists had collected data on many substances, they were convinced that matter didn't suddenly appear or disappear when it changed from one form to another. This gave them confidence that their measurements were useful.

But scientists don't just work with different forms of the same thing. In most of their work they change substances either by breaking them apart or by making new combinations. These are chemical changes that raise a new question. Want to guess what?

A. STIR UP A STRANGE BREW

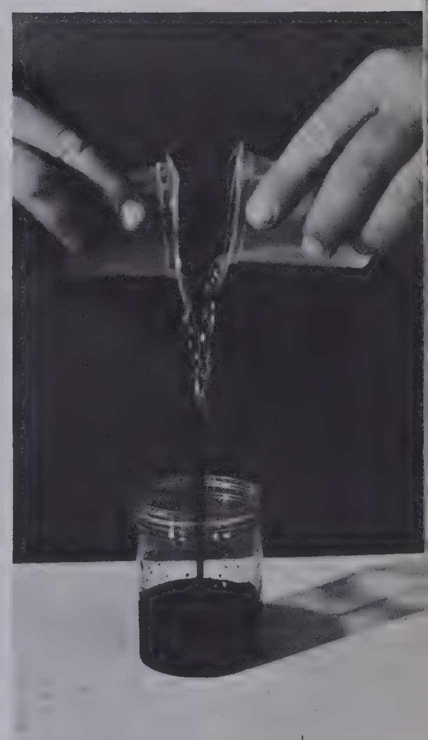
The question is: Does the amount of matter change when the substances themselves change? For instance, if you mix two chemicals to form a new chemical, do you still have the same amount of matter?

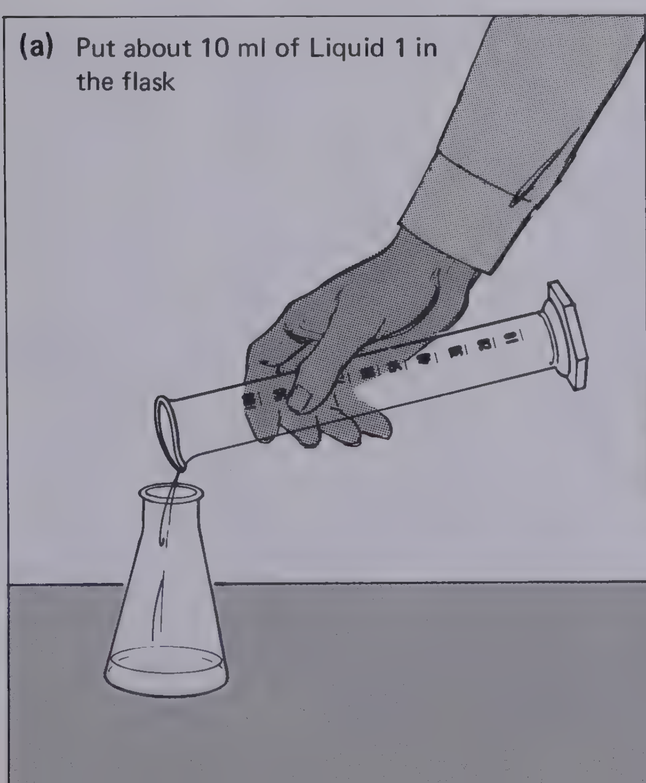
1. What is your prediction?

You will be given an Erlenmeyer flask and a test tube.

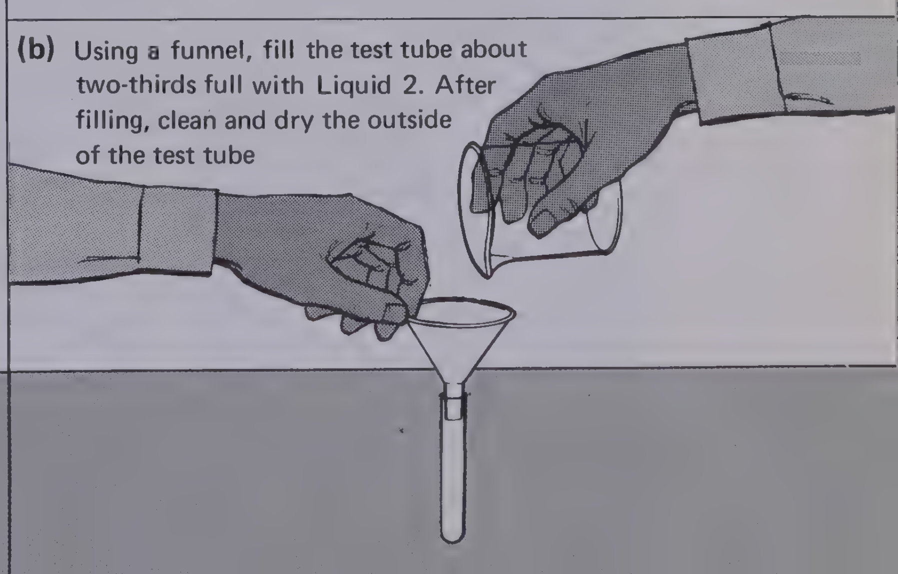
Union Carbide

Liquid Nitrogen Evaporates Directly Into the Air as an Invisible Gas

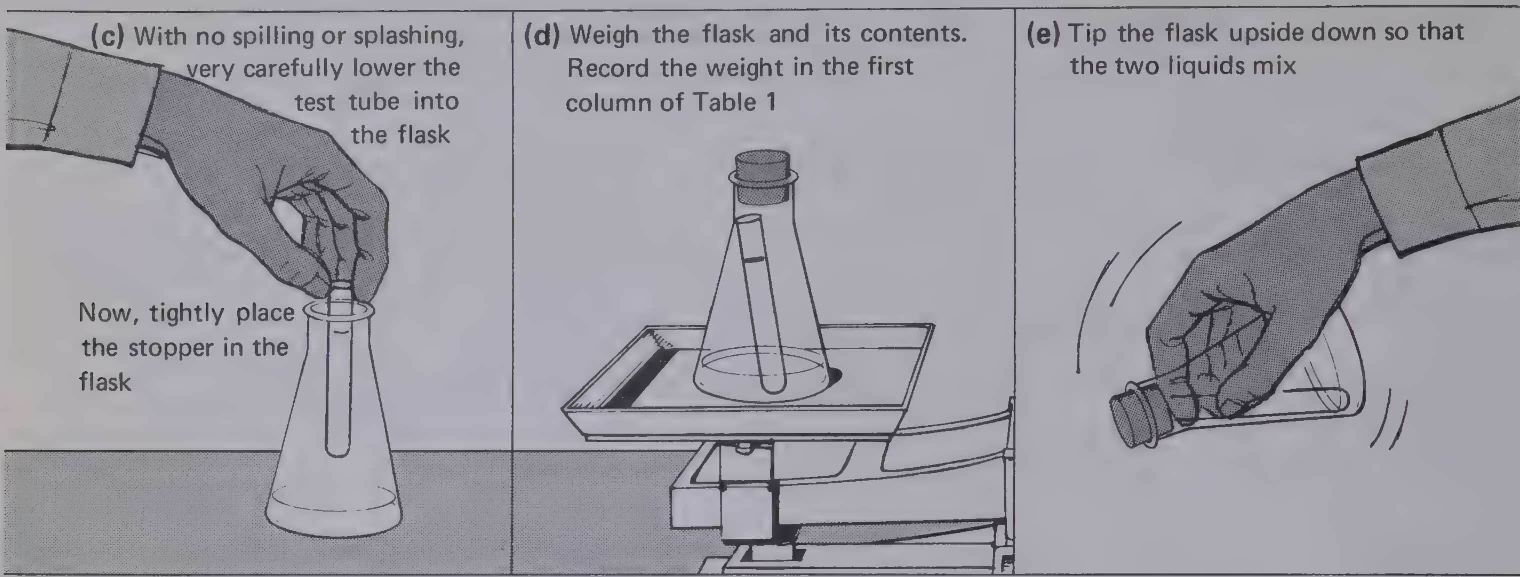




(a) Put about 10 ml of Liquid 1 in the flask



(b) Using a funnel, fill the test tube about two-thirds full with Liquid 2. After filling, clean and dry the outside of the test tube



2. What change do you observe?

Weigh the flask and its contents again. Record the weight, after mixing, in column 2 of Table 1.

Find the change in weight and record it in column 3. Have one member of your group record the change in weight in the data table on the board. Record the class data in Table 2.

3. What did Liquid 1 look like before mixing?

4. What did Liquid 2 look like before mixing?

5. What happened when the two colorless solutions were mixed—what changes in properties seem to have taken place? Explain.

6. Does the kind of matter in the flask appear to have changed? Explain.

B. AND YOU GET?

7. How do the results of the different groups compare?

8. Does the amount in the flask appear to have changed?

9. Did the results support your prediction? Explain.

10. Looking at the results of the last few investigations, what general statement can you make about the amount of matter present in a closed situation?

CONCEPT SUMMARY.

Investigation 6

One and One Don't Make Two

Let's see where we are. We know a few things about matter now. To review them:

a. Almost everything is made up of matter. All matter has weight and volume.

b. Density is the ratio of the weight of a sample of matter to its volume.

c. The amount of matter remains the same when it changes from solid to liquid.

d. The amount of matter remains the same regardless of what form it takes.

e. The amount of matter remains the same during a chemical change.

This information allows us to proceed with confidence. If a lump of rock weighs 57 g on Monday, it will weigh 57 g on Tuesday. But what is in the rock? How is matter put together? And just what is matter made of?

People have been wondering about this ever since man could take time to sit down and think. Men began to form opinions about matter, and with opinions came arguments. The one we are interested in started about 2,500 years ago. One side thought matter was continuous. This means that it can be divided into smaller and smaller pieces without ever stopping.

Ancient Greek Philosophers Discussed Atoms

Alinari/National Museum, Naples

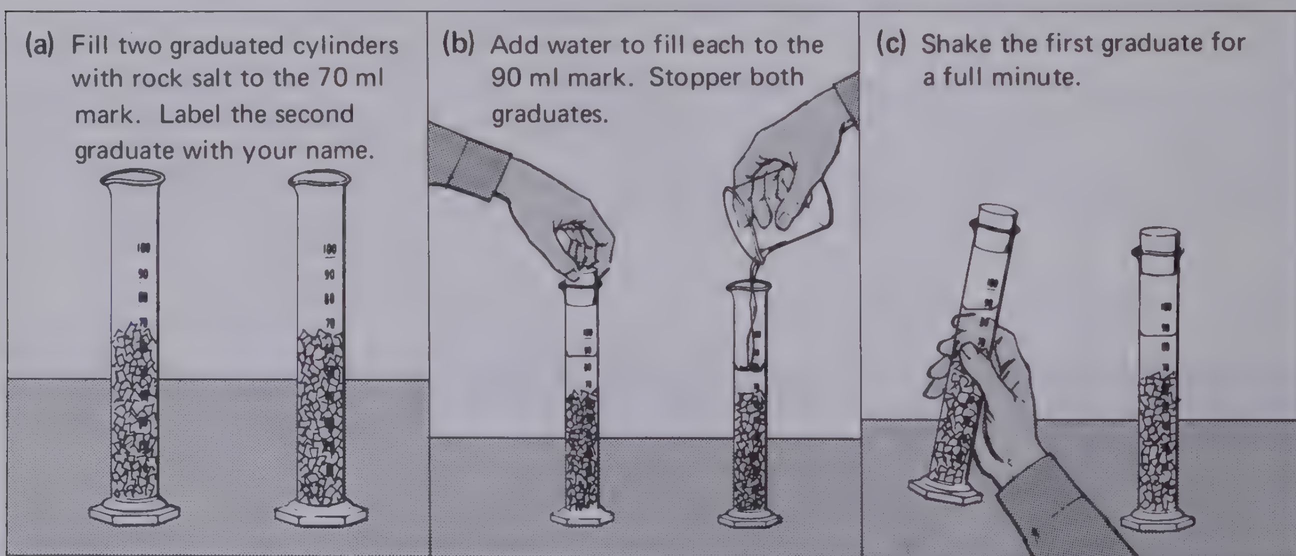
The other side couldn't see it that way at all. They felt there was a limit as to how small a piece of matter could be. There must be a tiniest particle of matter.

Suppose you could do an expensive experiment. Start by cutting a piece of gold in half. Throw one-half away. Cut what is left in half. Throw one of those halves away. How long can you keep this up?

Use your imagination. Pretend you have super eyes and can see the tiniest pieces. Is there a limit where you can't divide the gold any more? The particle side said "Yes"; the continuous side said "No."

A. A SALTY TALE

Putting a liquid and a solid together may tell you something.



(a) Fill two graduated cylinders with rock salt to the 70 ml mark. Label the second graduate with your name.

(b) Add water to fill each to the 90 ml mark. Stopper both graduates.

(c) Shake the first graduate for a full minute.

1. How high is the water level now?

Let the second graduate stand overnight without shaking.

2. What do you predict the water level will do: rise, fall, or stay the same?

3. Observe the water level in the graduate the next day. What is it?

4. Which idea does this data support, continuous matter or particles?

B. SCIENCE FOR BREAKFAST?

We have worked with liquids and solids so far. Now let's use solids only.

Fill a beaker about half full of water. Mark the level of the water with a marking pencil or with a piece of tape.

Empty the water into a larger container.

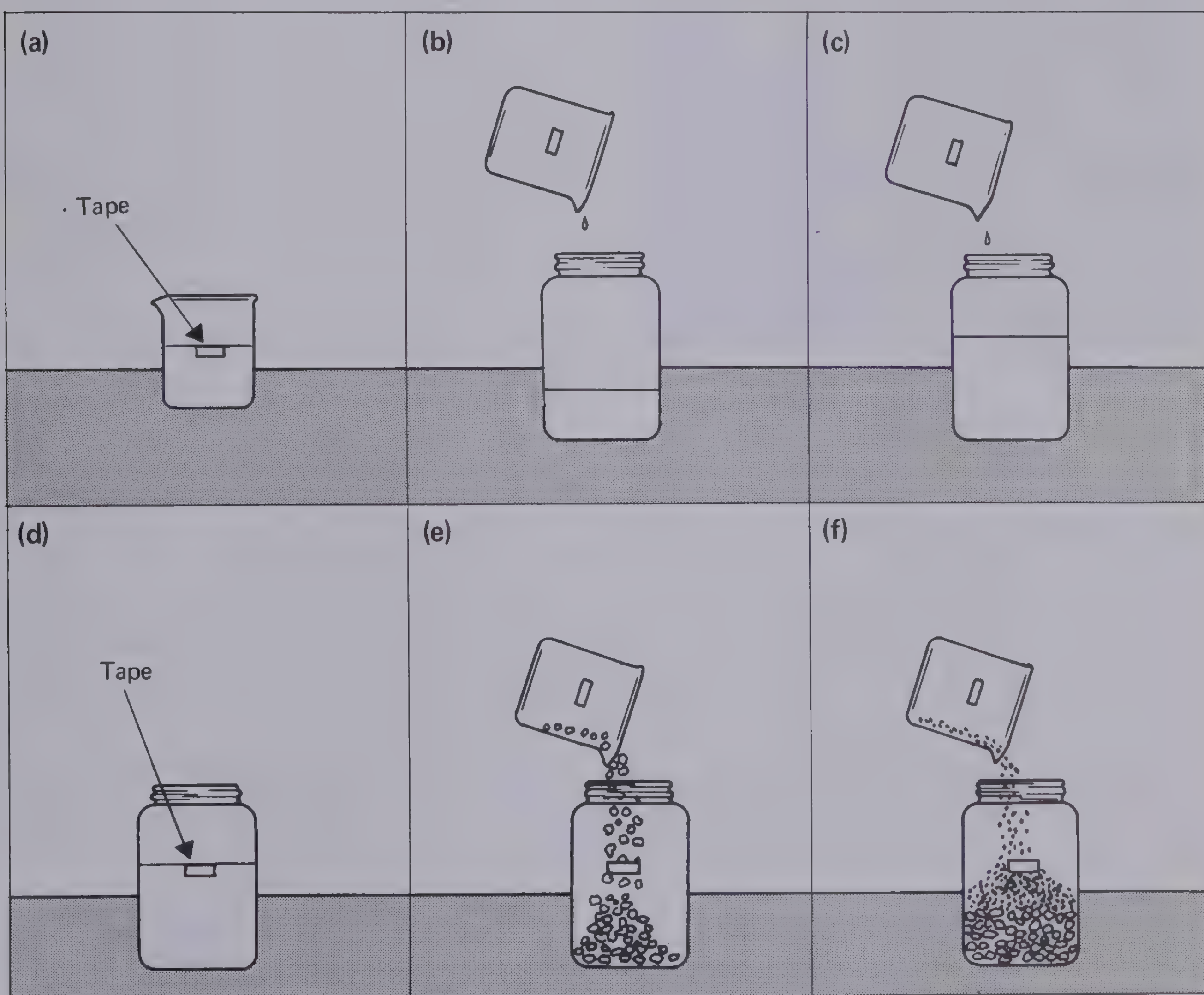
Fill the beaker again with water to the level of the mark. Empty the water into the larger container. You now have twice as much water in the larger container.

Mark the level. Empty the beaker and the larger container. Thoroughly dry both containers.

Fill the beaker to the marked level with popcorn. Pour the popcorn into the larger container.

Repeat this procedure with puffed rice or puffed wheat.

5. Is the jar filled to the mark?



Put your hand over the mouth of the jar. Give the jar a few hard shakes.

6. Now how close to the mark are the contents of the jar?

7. What did the pieces of popcorn and cereal do that made the total volume *change*?

8. What do you think happened with the salt and water?

Both parts of this investigation seem to show the same thing about matter.

9. Is this data easier to explain with continuous matter or the particle idea?

CONCEPT SUMMARY.

Investigation 7

It's a Gas

Now you know something new about matter. Different substances fit together as though they were made of particles. In other words, matter appears to be made of tiny parts, not of a solid, continuous mass. It's made of individual pieces, like cereal in a box. There are spaces between the pieces, or particles.

You might ask yourself again:

What are particles of matter like?

What's in the spaces?

Many experiments were performed which supported the idea of matter being composed of tiny particles. But ideas change slowly. Not everyone was convinced. Few people accepted the particle idea when it was first thought of, a couple of thousand years ago.

The scientists working on the problem of what matter was made of needed more information.

John Dalton (1766-1844)
Pioneered the Atomic Theory

All the data so far has been about mixing one kind of matter with another. When the two are mixed, no real change in the kinds of matter takes place. This is known as a *physical change.* Investigations 3 and 4 show physical changes. For instance, if you mix sand and water, or sugar and water, you do not get anything new. You just get sandy water or sugary water. If you dry up the water you can get back the sand or sugar. The same holds true if you mix two cereals together. If you have the patience, you can sort out the two cereals again.

But what would happen if particles of different substances were to stick together, or combine to form a new substance? You would get a *chemical change,* like the red solution in Investigation 5.

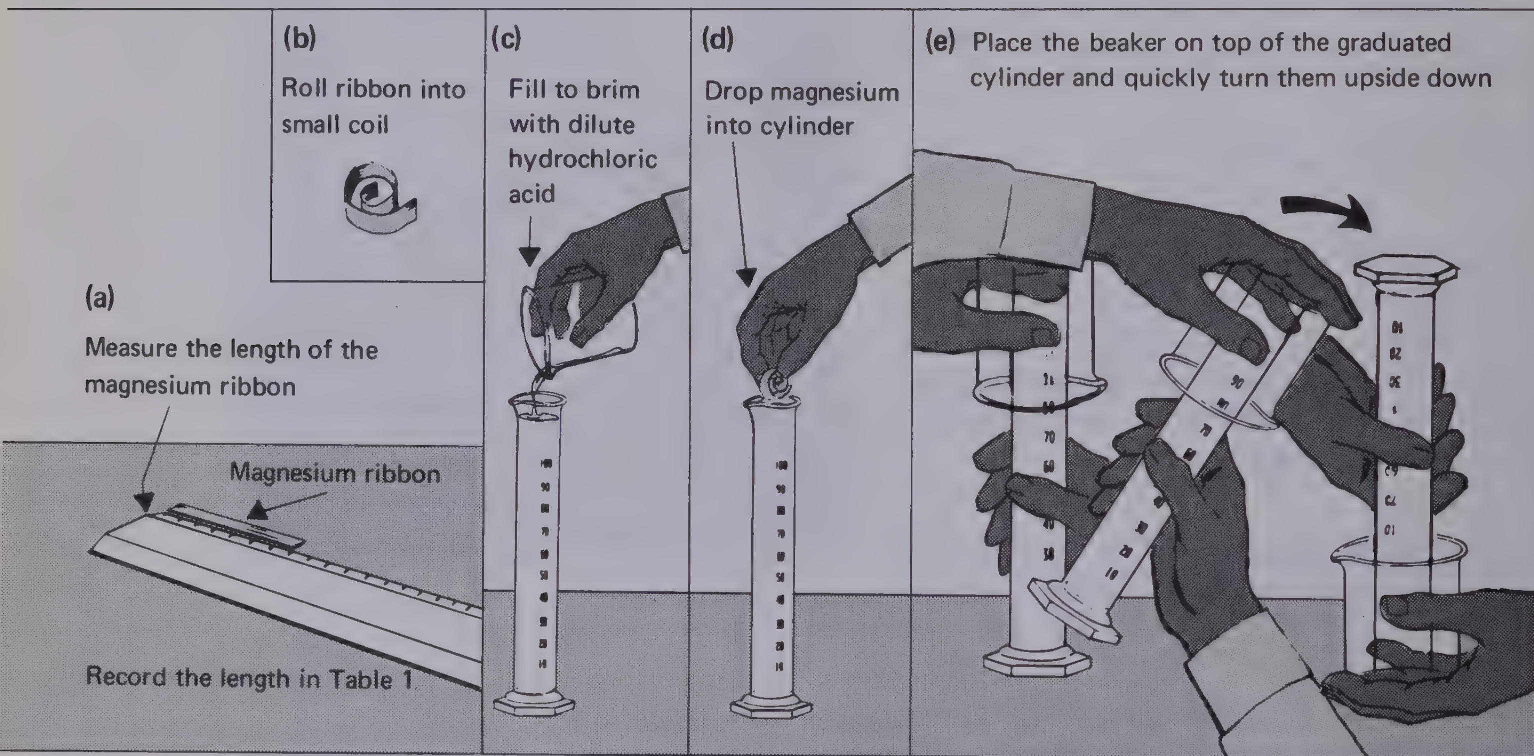
How do the particles of one substance combine with the particles of another substance? Is there any order in how many particles of one kind will combine with the others?

A. THE ACID TEST

1. Particles either combine in some order or they do not. What do you predict?

Test your prediction. You will be working with magnesium and hydrochloric acid. The acid won't make instant holes in your hands, but wash them when you are finished, because it could make your skin itch or tingle. It could also damage your clothes and hurt your eyes. Better not put it in your mouth.

BE CAREFUL WITH ACID.



2. Describe what happens.

Calculate the total volume of gas collected in the graduated cylinder and record it in Table 1.

Have someone in your team record in the class data table on the board the length of the ribbon and the total volume of gas collected. Record this same data in Table 2.

Make a graph of the class data on Graph 1. Go up the graph and find the point that shows the milliliters of gas that were collected. On a line to the right of this point find another point that tells how many centimeters of ribbon were used. Mark the one point that stands for both these amounts. Do this for each team. Connect all the points with a smooth line.

3. What general shape does the graph seem to have?

If your graph shows some definite shape, instead of a jumble of points, it means that there is a relationship between the two values plotted. What is this relationship?

Refer to the class data you wrote in Table 2. In each column, divide the total volume of gas produced by the length of the ribbon. Put the results in the bottom row.

4. What do the ratios in the bottom row of Table 2 have in common?

5. How do you think the particles of one substance combine with the particles of another substance?

B. WHO CARES?

Should you worry about how things combine? The instructions on a cake mix say, "Add two eggs and one cup of water."

6. What would the cake be like if you added 1 egg and 3 cups of water?

7. To mix concrete for a sidewalk, the proportions run 5 sacks of sand and gravel to 1 sack of cement. What kind of a sidewalk would you expect if 12 sacks of sand and gravel went with each sack of cement?

Making cake and concrete are both chemical reactions. So is baking meat loaf, developing Polaroid pictures, and burning gasoline inside a car's engine.

8. How well does a car run if the air-to-gas mixture is not set right in the carburetor? What kind of mileage will you get?

9. What would happen if particles did not combine in a regular way?

C. MEANWHILE, BACK IN THE TEST TUBE

You have collected data on combining materials. You know something about the amount of one that goes with a certain amount of the other.

10. How did your prediction in question 1 (about how particles combine) work out?

CONCEPT SUMMARY.

Investigation 8

Let's Break Something

Old ideas die hard. Just look at the many ideas people have today that are based upon superstition and prejudice.

For a long time people believed that matter was continuous. It took a large body of data to wear them down.

People also were not sure that different kinds of matter combined in regular ways. Showing that one acid and one metal combined in constant proportions was not enough. There were thousands of substances that reacted with each other. They all had to be tested to see if the idea of constant proportions was valid.

But whenever careful measurements were made, constant proportions were found. With so much data, scientists could agree that matter unites in constant proportions. (To illustrate what is meant by constant proportions, if one class eats up two sacks of popcorn, then two classes will eat up four sacks and so on.)

We discovered this important concept in our last investigation. How does the idea of constant proportions tell us that matter is made of particles?

A. BREAK IT UP

1. Suppose matter is not made of tiny particles. How can two substances combine?

2. Suppose matter *is* made of tiny particles. How can two substances combine?

3. Think of a substance that is made up of two different kinds of particles that have combined in a certain ratio. It might be 3 to 1, or 4 to 1, or any other ratio. Make a prediction about the amounts of the two different kinds of material that will be collected when that substance is broken apart again.

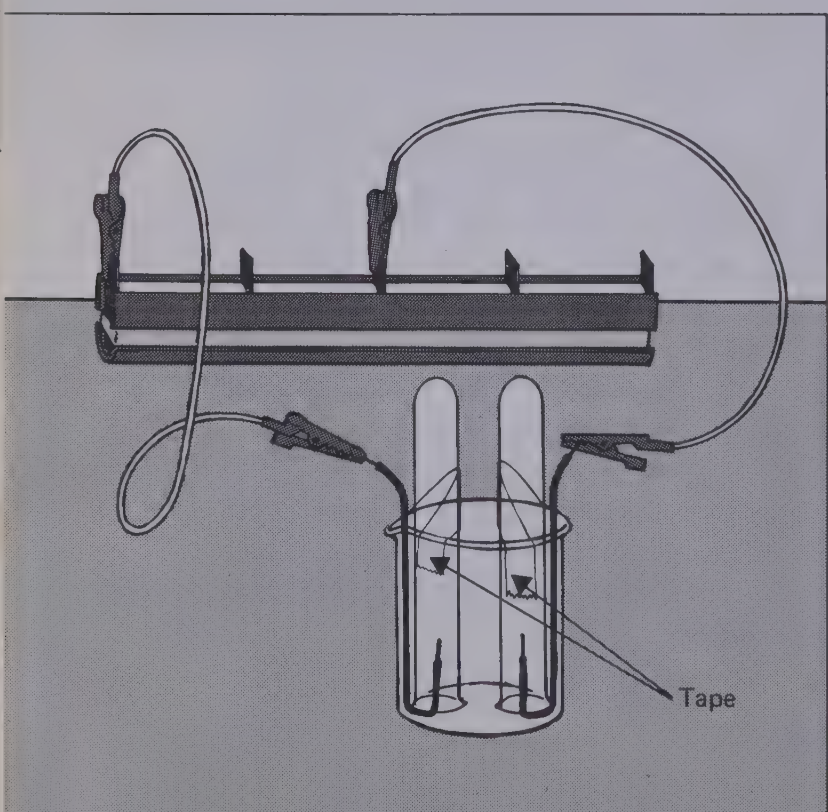
You will be given a set of batteries. Instructions on how to connect these batteries to your electrodes will be given in class. Do not make the connection until you have read what follows.

Fill a beaker half full of a solution of sodium carbonate (washing soda) in water. (It is the water that will break apart. The sodium carbonate just speeds up the process.)

Put two electrodes into the beaker on opposite sides, so that their tips are an inch or so below the water surface.

Fill a test tube to the brim with the same solution of sodium carbonate. Put a little piece of paper towel over the top—just enough to cover it and stick. Turn the test tube upside down and dip it into the solution in the beaker. Remove the bit of paper towel. Place the upside-down test tube over an electrode without letting any air get in. Attach the test tube to the side of the beaker. Do the same thing with the other test tube over the other electrode.

Now connect the electrodes to a two-battery hookup and watch the fun!



4. What happens?

Reconnect on a one-battery hookup.

5. What happens?

Connect the number of cells assigned to your team. Let the reaction run for at least 10 minutes. Record in Table 1 the time you start and stop the reaction.

Measure and record the amount of gas in each test tube. The tube having the larger volume of gas is over the negative electrode.

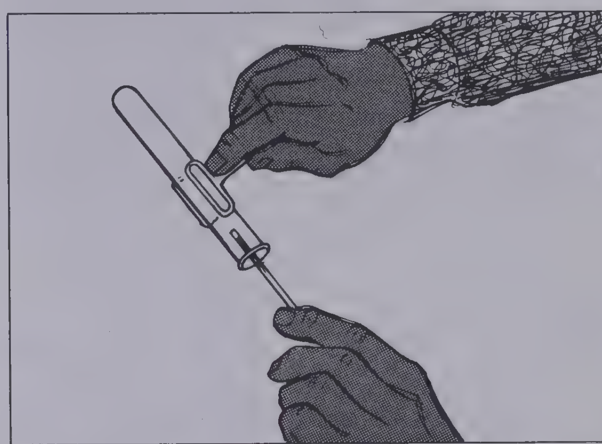
If time permits, run a second trial.

Have someone from your team record the data in the class data table on the board. Record the class data from the board in Table 2.

B. MEANWHILE, BACK AT THE TUBES

What about the gases collected in the tubes? Work with another team for this part.

Light a splint and while it is burning, carefully remove the negative test tube from the beaker. Keep the tube pointed down. Hold the flame near the mouth of the test tube. Slowly tip the test tube sideways while holding the flame at the mouth.



6. What happened?

7. Have the team of students at another table blow out the flame and insert the glowing splint into the negative tube. What happened?

8. Was there a difference between using a glowing splint and a flaming splint? Explain.

9. This time apply the *burning* splint to the *positive* tube. What happened?

10. Have the team at another table insert the *glowing* splint into the *positive* tube. What happened?

11. Are the gases in the positive and negative tubes the same? Explain.

12. What gas do you think is in the negative tube? Why?

13. What gas do you think is in the positive tube? Why?

Wide World Photos

Hydrogen-filled Zeppelin "Hindenburg"; Lakehurst, N.J., May 6, 1937

C. WHO NEEDS GAS?

You have found that gases are formed when electricity passes through water. We may not spend much time worrying about what water is made of, but we do spend time worrying about such things as fixing the car. Does gas from electricity come in here? If you work around car batteries you soon get the word. Watch out for sparks around batteries on the charger.

Educational Affairs Dept. Ford Motor Co.

14. Why would a spark be a problem near a battery with current passing through it?

When the frame of your car needs welding, the torch used burns two gases. One of them is acetylene.

15. What is the other gas?

16. How do you think the other gas is produced?

You don't have to be an astronaut to get special air to breathe. All you have to be is sick.

17. What gas is used in hospitals for pneumonia and heart attack cases?

18. How do you think this gas is produced?

D. HOW'S YOUR PREDICTION?

19. How does the amount of gas collected at the negative electrode compare with the amount at the positive electrode?

20. What was the ratio of gases?

21. What ratio of gases did the other teams collect?

22. What relationship is there between the running time and the amount of gas collected?

23. Does the number of batteries used change the ratio of gases collected? Why?

24. When the matter, water, was broken apart, what pattern was there to the results?

25. Does your data support or reject your prediction in question 3? Explain.

CONCEPT SUMMARY.

Investigation 9

Don't Go to Pieces

We have collected quite a bit of information about matter. Whether it's soap suds, clouds, pebbles, wood—you name it—what we can say about one kind of matter we can say about all kinds of matter.

a. All matter has weight and volume.

b. Density is the ratio of weight to volume.

c. The amount of matter remains the same when it changes from solid to liquid.

d. The amount of matter remains the same regardless of what form it takes.

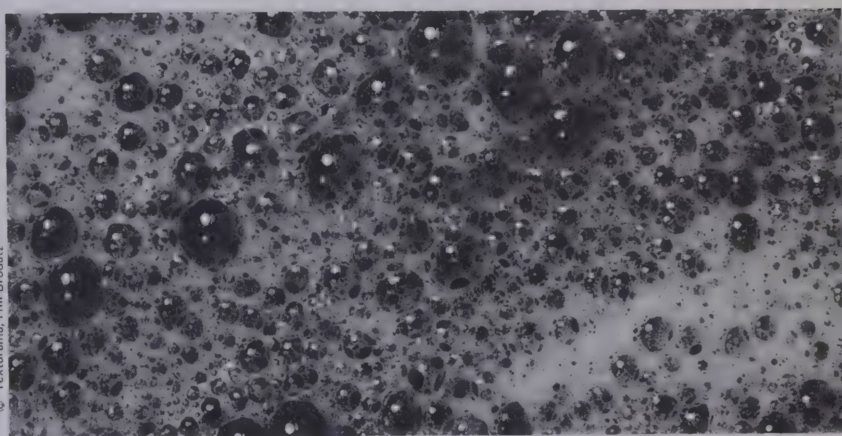
e. The amount of matter remains the same during a chemical change.

f. Different kinds of matter fit together as though they were made of particles.

g. Some substances combine with each other in constant proportions.

h. Matter breaks down in constant proportions.

Where do we go from here?



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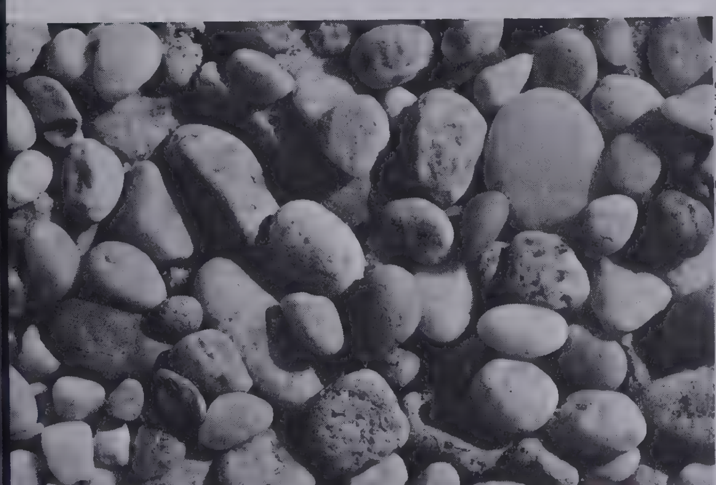

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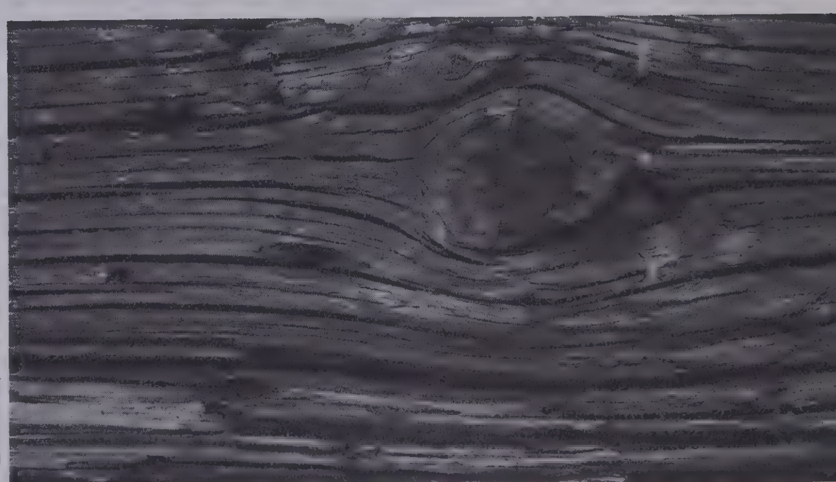

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The last three concepts may fit a common pattern. Maybe matter *is* made of particles and these particles join up or break apart in constant proportions.

When you break matter apart, do the parts have anything in common? How can you tell what the different parts are?

A. TAKE A POWDER

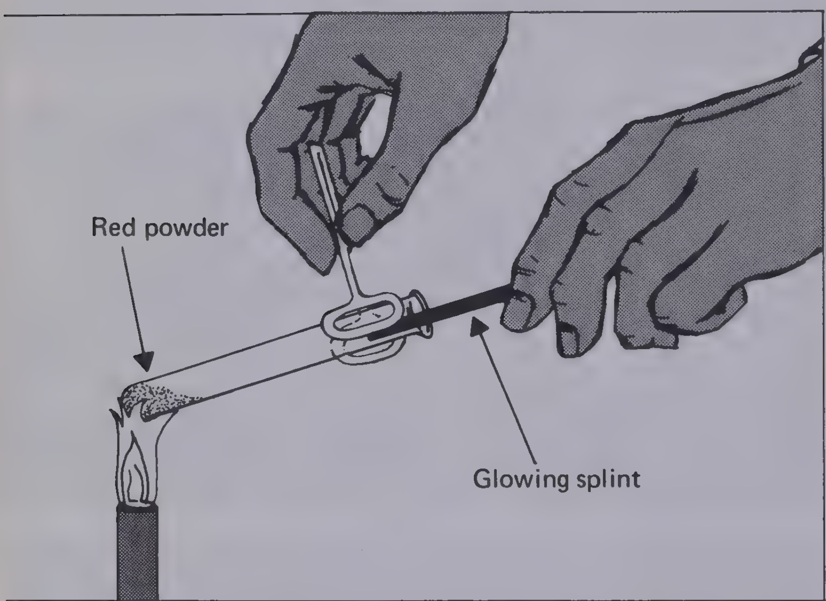
DO NOT PUT ANY OF THIS MATERIAL NEAR YOUR MOUTH.

Fill a test tube one-half centimeter deep with red powder. Heat the test tube over a hot flame.

1. Describe the material collecting on the walls of the tube.

2. What do you think this material is?

3. While heating the tube over the flame, place a glowing splint in the tube. Describe what happened to the glowing splint.



4. You have seen this happen before. What substance do you think is given off when the red powder is heated?

5. Do you think the red powder is made of one kind of matter or more than one? Explain.

B. A REAL FIZZY PARTY

Fill a test tube one-quarter full of the dilute acid solution. Add a small amount of the yellow powder.

6. Describe the reaction.

7. While the mixture is still reacting (if it stops add some more powder), put a glowing splint into the mouth of the test tube. What happened?

8. Do you think this is the same gas as in part A? Why?

9. Is there any material left in the tube? How do you know?

10. Do you think the two substances put into the test tube are made of only one kind of matter, or more than one? Explain.

C. THE SAME GLOWING THING

We broke apart different substances in this investigation. We broke apart another substance in the last investigation. In all three cases, a gas was produced.

11. Was it the same gas each time? How do you know?

12. Which of these statements is true?

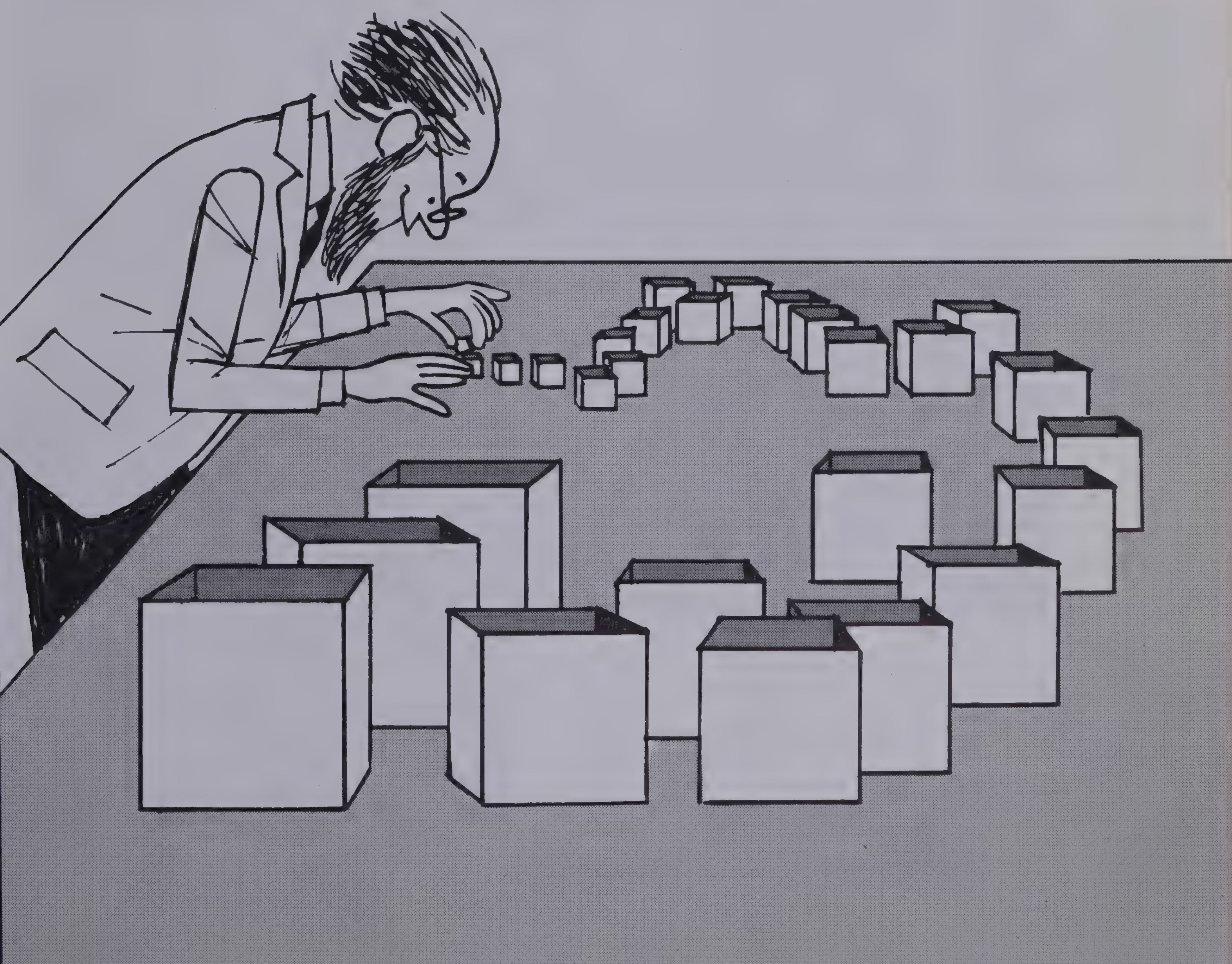
   a. The same substance can be found in different kinds of matter.

   b. One kind of matter can be composed of several different substances.

What we did in this investigation was to break down one kind of matter into its basic substances. There are about 100 of these. Everything in the world is made of combinations of these basic substances.

13. What do scientists call these basic substances?

14. What do we call the tiniest particles of these basic substances?



Scientists keep on being curious. Is there more to the story?

15. Now make a prediction. Are the particles you named in "14" really the tiniest, or are there still other tinier particles?

CONCEPT SUMMARY.

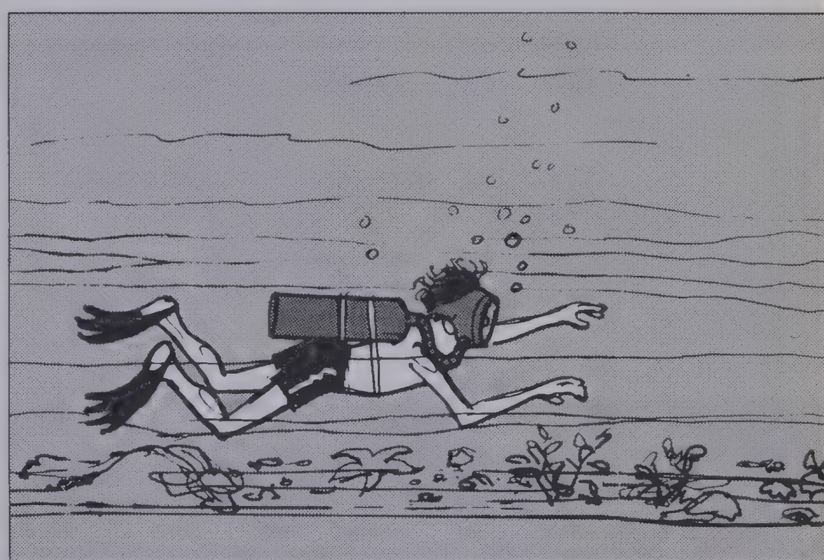
Esso Research and Engineering Co.

Investigation 10

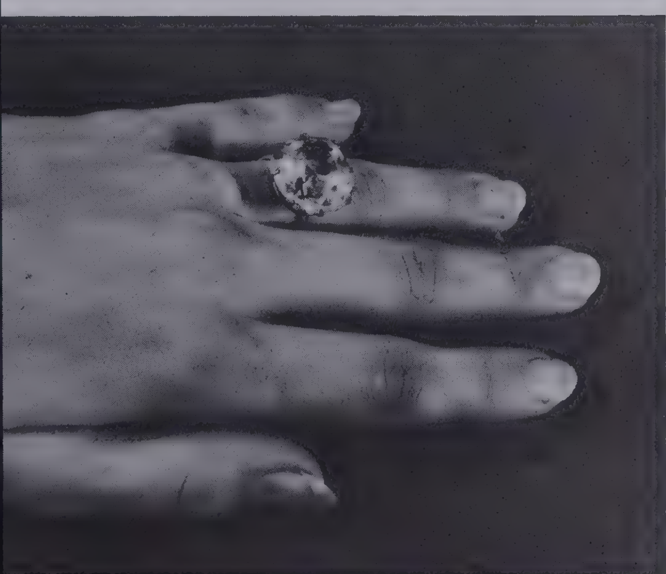
What Goes on in There?

We are now at the point at which scientists studying matter made one of their most important breakthroughs. They had collected enough data to decide that matter was made of tiny, invisible particles, the atoms.

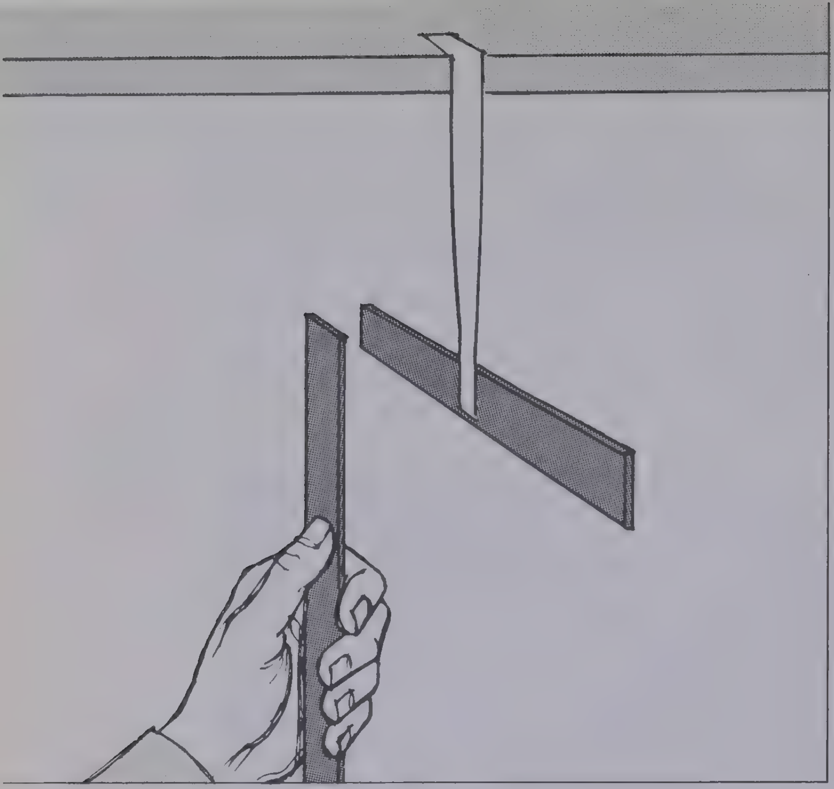
There are about 100 kinds of matter, the elements. Each element is composed of large numbers of its own kind of atom. Each element's atoms are different from the other 99 or so kinds of atoms. You already know many of the elements. The element iron is the metal that tools, machines, cars, and a million other things are made of. The element aluminum is used for making wrapping foil and pots and pans. Copper is the shiny red metal in wire and pennies. Oxygen, the important gas you breathe for life, is an element. Carbon is the element in coal—and diamonds.



You can probably name about a dozen or so more without half trying. All metals are elements. Phosphorus, sulfur, iodine, silicon are all elements. The 100 or so different kinds of atoms of the elements represent the building bricks of matter. It takes two different kinds of atoms to make water. It takes three kinds of atoms to make sugar. It takes about 20 kinds of atoms to make you!



So now we come down to the question: What is there about different atoms that makes the differences among the elements? Why are the atoms of one element different from those of another? Maybe atoms are not the end of the line. How could information be gathered to solve the problem of what an atom is like? Help came from an unexpected direction. Scientists working in electricity came up with information that provided clues to this problem.



A. AYE, THERE'S THE RUB

Use tape to hang one piece of white plastic about ten inches down from the edge of the table, evenly balanced. Rub it and the other white piece with the wool cloth several times in the same direction. Slowly bring the end of the piece that is not hanging toward an end of the hanging piece.

1. What happens?

There are two kinds of electric charge: positive and negative. When you rubbed the pieces of plastic you gave each one a charge.

2. Did each get the same kind of charge, or different charges?

Now do the same thing using the two pieces of clear plastic and the cotton cloth.

3. What happens when you bring the end of the clear plastic you are holding near an end of the hanging clear plastic?

4. Would you say the two pieces of clear plastic each got the same kind of charge, or different charges?

Now take one piece of clear plastic and one piece of white plastic. Hang one of them.

5. If the white plastic and the clear plastic each have a positive charge, what happens when they are brought together?

6. If they each have a negative charge, what should they do together?

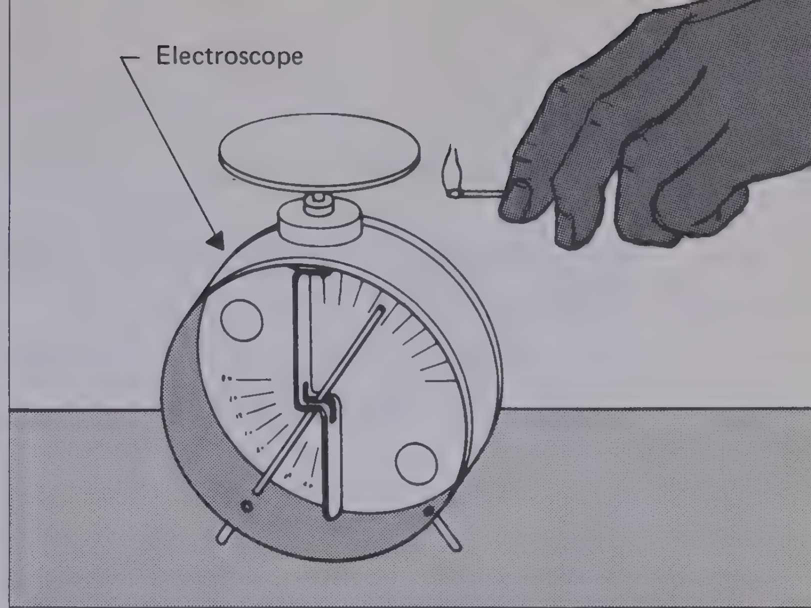
7. If one has a negative charge and the other a positive charge, what do you predict they will do together?

8. Try it and see. What happens?

9. Do you think the white plastic and the clear plastic have the same charge, or opposite charges?

10. What do objects having the same charge do?

11. What do objects having unlike charges do?



12. Would charged objects show the same pushing apart and pulling together if they were much smaller than the pieces of plastic you used?

13. If they were the size of specks of dust?

14. What do you think the smallest thing is that can hold a charge?

B. HOW DO YOU CHARGE?

You have just demonstrated electrical charge. You know that when objects have the same charge they push away from each other. This last piece of information can be used in a device for showing the presence of charge. It is called an electroscope.

Electroscopes come in many models but they have one thing in common. They are delicate. Wait for instructions before you start working with yours.

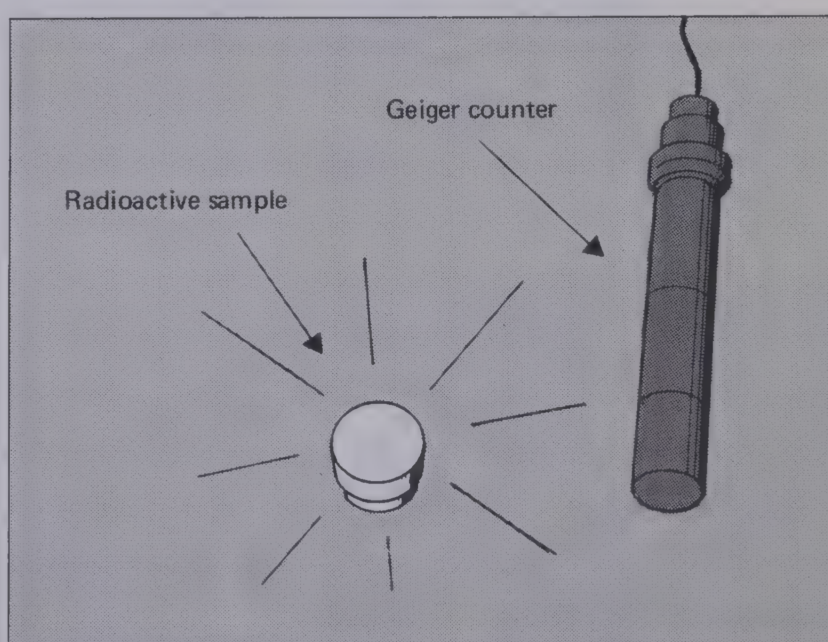
15. Rub the test tube with the silk. Bring the test tube close to the knob or plate on the electroscope. What happens?

16. Try touching the test tube against the plate or knob. Find a way to make the electroscope stay charged. After the electroscope is charged, let it stand for about 5 minutes. Does it discharge?

17. Charge the electroscope again. Hold a match flame near its knob or plate. What happens?

18. Charge the electroscope once more. This time use a plastic strip. Hold the flame near the electroscope again. What happens?

Scientists believe that in a flame atoms are rubbing and bumping each other like mad, and forming new combinations. They may even be knocking pieces out of each other.



19. If a flame discharges an electroscope, what may be happening between the flame and the electroscope?

C. TOO FAST TO COUNT

Set out the Geiger counter, and turn it on.

20. The equipment may be detecting something. What do you observe?

Set the detector on the table and put a radioactive sample right next to it. Make sure it's turned on.

21. What do you observe this time?

22. Move either the detector or the sample so that they are no longer right next to each other. What do you observe now?

Place the detector and the sample right up against each other. Place various spots on the detector next to the sample, and find the spot that seems to be the hottest.

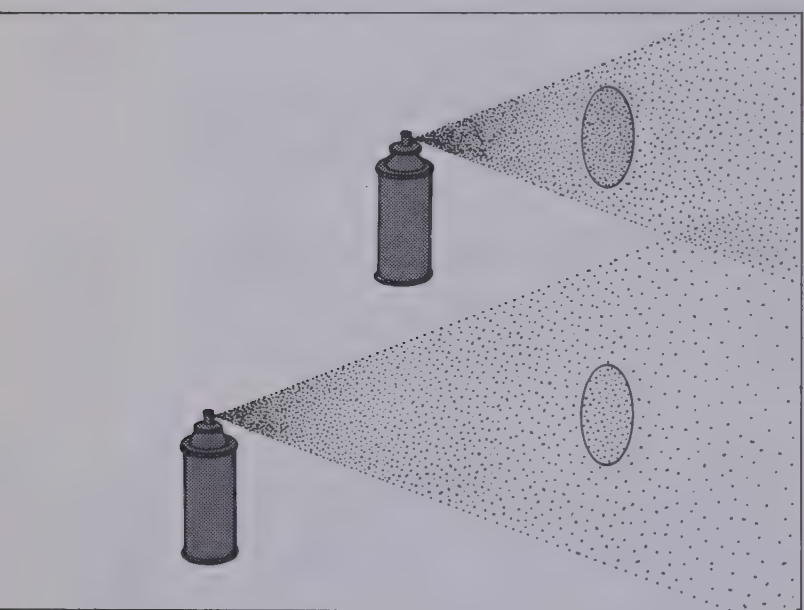
23. Where is the hottest spot?

Put the hot spot of the detector right next to the sample and observe. Then move it away a couple of inches.

24. What happens?

25. Move it back close again. What happens?

Keep moving the detector and the sample to get ideas of what may be happening.



26. As you move the sample closer to the hot spot, what do you observe?

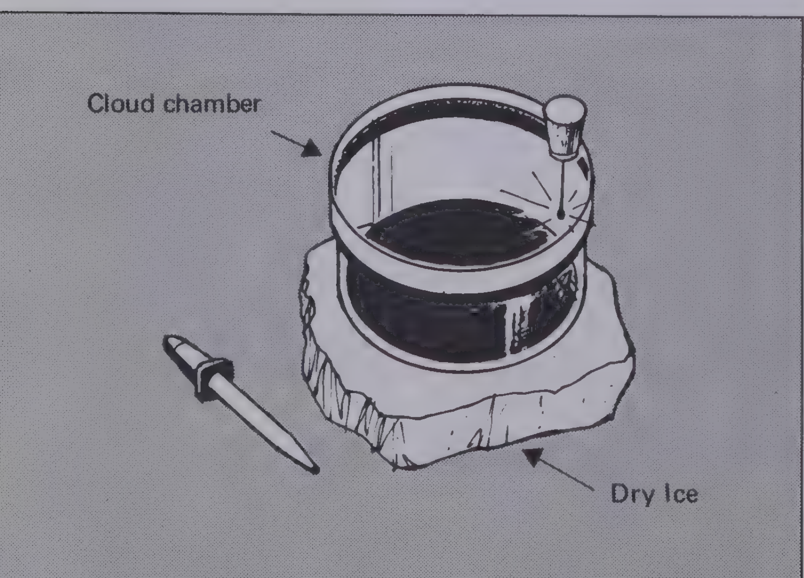
27. Will a paint spray can put more drops of paint into a one inch circle at one foot or after you move back to two feet?

28. With the spray can as a clue, how would you explain the fact that you get a greater measure of radiation when the hot spot is close to the sample?

D. CLOUDS IN YOUR CHAMBER

Now that you've heard particles shooting out of atoms, how about taking a look at them?

Scientists use a round plastic box called a cloud chamber to look at atomic particles. To prepare the chamber, the spongy band around the inside at the top is moistened with very pure ethyl alcohol. The band must be well soaked, but not so wet that alcohol drips down the side. A small amount of radioactive material has been put on the end of a wire. This wire is plugged into the box, and the box itself set on top of a piece of Dry Ice. Then the chamber is allowed to get cold for a few minutes.



The room will be darkened and a flashlight aimed through the cloud chamber, about parallel to the table, but pointing down slightly. Watch for a while.

29. What did you see?

The radioactive source will be removed for a moment.

30. When this was done, what did you notice?

The radioactive source will be put back in place.

31. With the source in place again, what happened?

32. What seems to be causing the tracks you saw in the cloud chamber?

33. What do you think they were the tracks of?

34. In what way is a Geiger counter like a cloud chamber?

E. WHAT'S LEFT AFTER THE FLASH?

When scientists analyzed radiating materials they were puzzled. The elements were not the same after they radiated. Their atoms seemed to have shot out particles smaller than the atoms themselves, and in so doing turned into different atoms. The new atoms were not radioactive.

Scientists are always more secure when they can measure something. They measured how long the elements that radiated would last before they became something else. Table 1 shows data for one radioactive substance.

TABLE NO. 1

REMAINING RADIOACTIVE MATERIAL AT SELECTED TIME INTERVALS

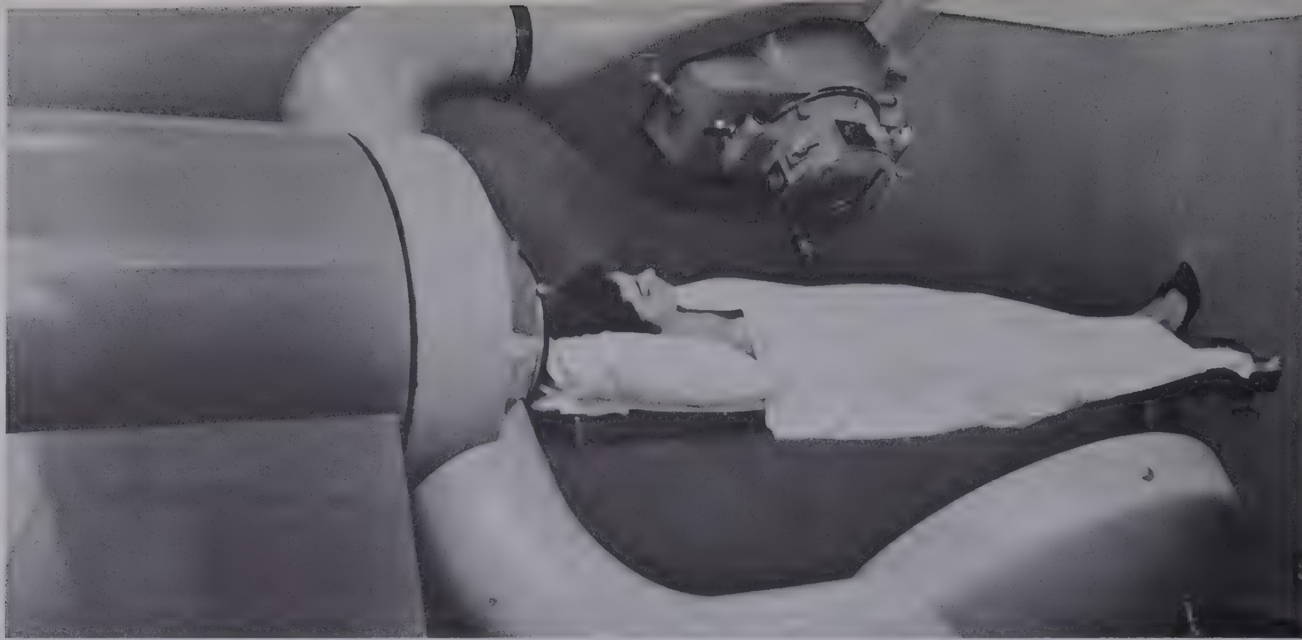
Days Gone By (from Start)	Start	14	28	42	56	70	84
Weight in Grams	2,000	1,000	500	250	125	62.5	31.25

Use the data in Table 1 to make Graph 1. Mark seven points, each showing the correct weight in grams of material that is still radioactive for the given number of days. Connect the seven points with a smooth curve.

35. Describe the shape of the graph.

36. How can the graph be used to tell how much radioactive material will be left at any time?

37. What does the curve predict about how long the radioactivity will last?


University of Texas

Cobalt-60 Treatment for Cancer

When an atomic bomb is tested above ground, radioactive material is thrown into the atmosphere. Some of the particles are so tiny they may float in the air for years. This material has been detected all over the world. A graph may be drawn like Graph No. 1 to illustrate it. The times across the bottom would be in years, not days.

38. If you were a Public Health scientist, how would you use Graph No. 1 to tell when one-half the amount of radioactive material remained?

39. What else about radioactivity should you know besides how to read the graph?

40. Mention some effects of radioactivity that are not bad.

CONCEPT SUMMARY.


Joint Task Force One

Investigation 11

Make Your Own Pieces

This is the situation. We have data that show that atoms contain smaller particles. We know that some of these particles have electrical charges. Some are positive, others negative.

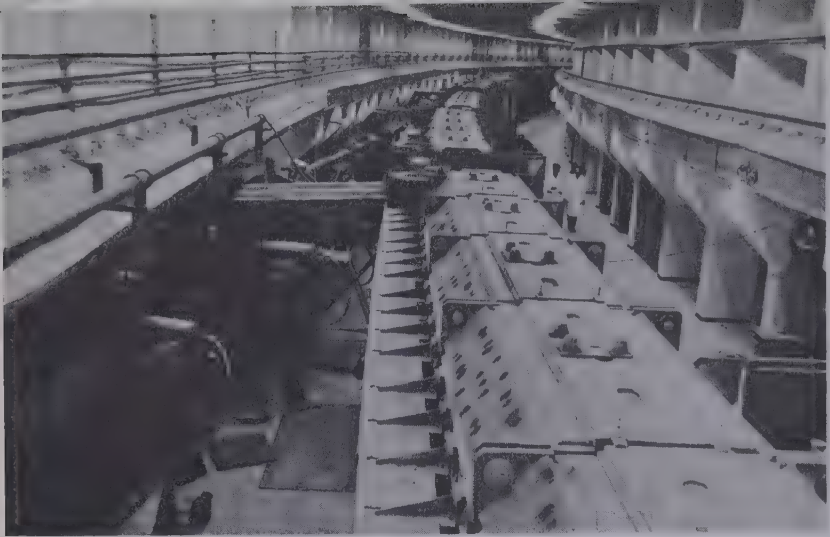
This information comes to us from experiments with electroscopes, Geiger counters, and other methods of detecting and measuring radiation.

But we don't know how these bits and pieces fit together to make an atom. You just can't pick up an atom and look inside. The methods of inspecting the insides of an atom will have to be different.

Radioactive elements found in nature gave the scientists a clue. They could identify particles that came flying out of atoms.

A. SCIENCE IS MARBLES?

Suppose a truck has crashed clear through a building. If you could only see the truck and not the building, then inspecting the truck might tell you quite a lot about the building.

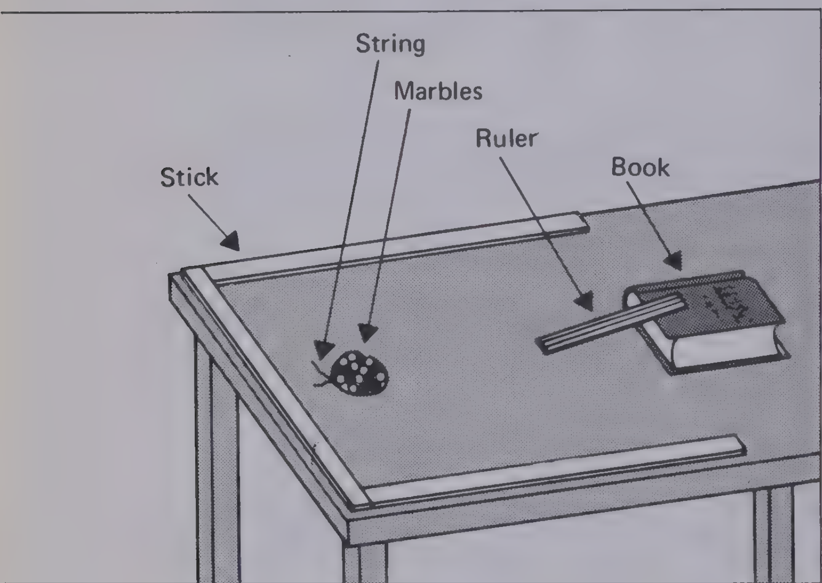


World's Biggest Accelerator: 76 GeV Synchrotron; Serpukhov, USSR

1. If the front of the truck had detergent, oranges, milk cartons, breakfast food, lamb chops, and cake mix on it, what was the building?

This was the logic of the scientists. They would learn what was in the atom by what they could knock out of it.

At first they used the fast-moving particles from naturally radioactive substances. Later they built powerful machines that revealed other particles.



What we want now is an idea of how this system works. We can get that by using objects large enough to see.

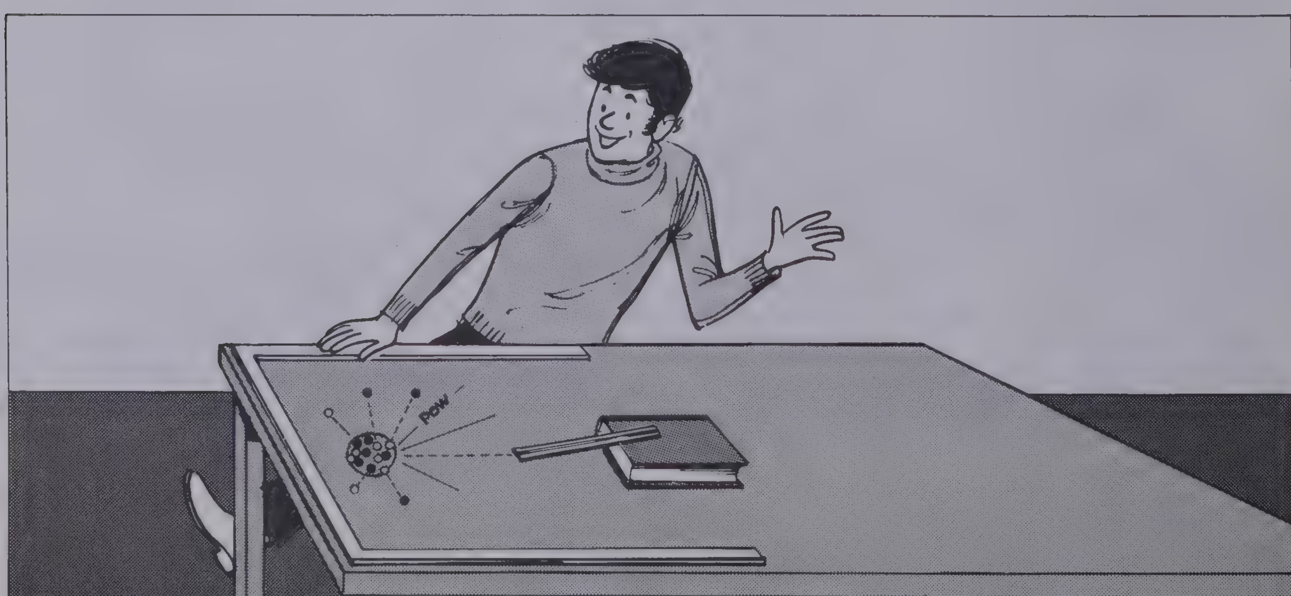
Set three sticks around the end of a table to act as barriers.

Take twenty marbles. You should have ten of each color. Mix them up. Place them in a round loop of string just big enough to hold them. Draw a chalk mark around them, and remove the string.

Set a plastic ruler at an angle with one end on some books. Aim the ruler at the marbles. Keep the ruler at the same angle all the time.

2. Why keep the ruler at the same angle all the time?

Use an odd-colored marble as your missile. Let it roll down the ruler and hit the cluster of marbles. Count the number of marbles of each color that come out. Record these as Trial 1 of Combination 1 in Table 1.



Put all the marbles back in the loop, and bombard them again. And then again. Record data for 15 trials under Combination 1. Now change the marbles in the loop. Put in 5 light and 15 dark marbles. Be sure they are mixed up. Bombard them 15 times and record the data under Combination 2.

Change the marbles one more time. This time use 15 light and 5 dark marbles. Make 15 trials and record the data under Combination 3.

B. WHAT CAME OUT OF WHAT WAS IN?

Find the average for each combination. Put the results in Table 2.

The ratios of light to dark you started with were:

a. 1 to 1

b. 1 to 3

c. 3 to 1

3. How do the ratios of colors knocked out compare with the ratios you started with?

4. Do you think a scientist is justified in believing there is a connection between the particles he knocks out of atoms and what is inside of them? Defend your answer.

C. SO IT'S LIKE THIS

When scientists analyzed the results of bombarding atoms with parts of other atoms, they were able to construct a picture of the atom. The important points were:

a. Three kinds of particles make up an atom—protons, neutrons, and electrons.

b. The proton has a positive charge.

c. The neutron has no charge.

d. The electron has a negative charge.

e. The proton and neutron have about the same weight.

f. The electron is much lighter than the other two. It takes over 1,800 electrons to weigh as much as a proton.

g. Most of the matter in the atom is concentrated in a tiny core, the nucleus.

h. The protons and neutrons are in the nucleus; the electrons are outside.

5. If the nucleus is only protons and neutrons, what is its electrical charge?

Cosmic rays are particles reaching us from outer space. They seem to be nuclei of ordinary atoms like hydrogen and helium.

6. What does this suggest about matter in the rest of the universe?

CONCEPT SUMMARY.

Spiral Nebula

Field Ion Photomicrograph of Tungsten Crystal

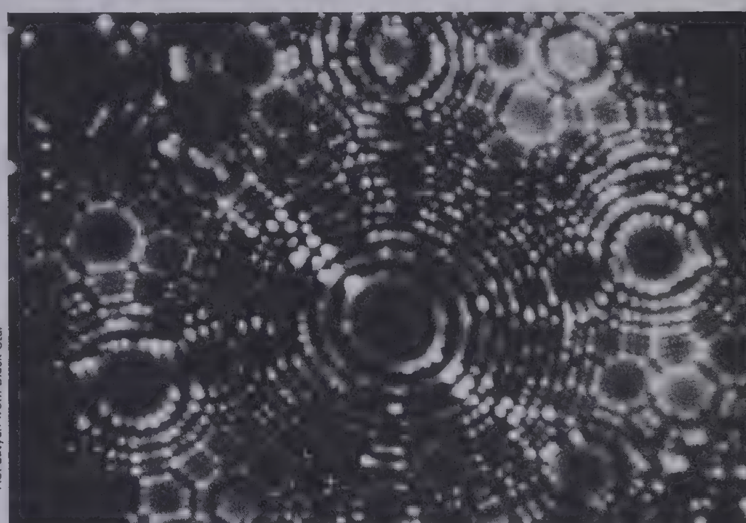
Idea 3
Energy

Investigation 1

I Could Watch It by the Hour

Things are not always what they seem. The solid-looking matter that everything is made of, including ourselves, is really trillions of tiny particles held together by electrical attractions. These particles are atoms, which are made of still smaller particles: electrons, protons, and neutrons. These particles are the same whether they are in your backyard, or Tibet, or the moon.

Looking inside atoms: field ion photomicrograph of a tungsten crystal



T.S. Satyan from Black Star

Buddhist monks in Lhasa, Tibet

Dr. Eugene S. Machlin

NASA

Kosti Ruohomaa from Black Star

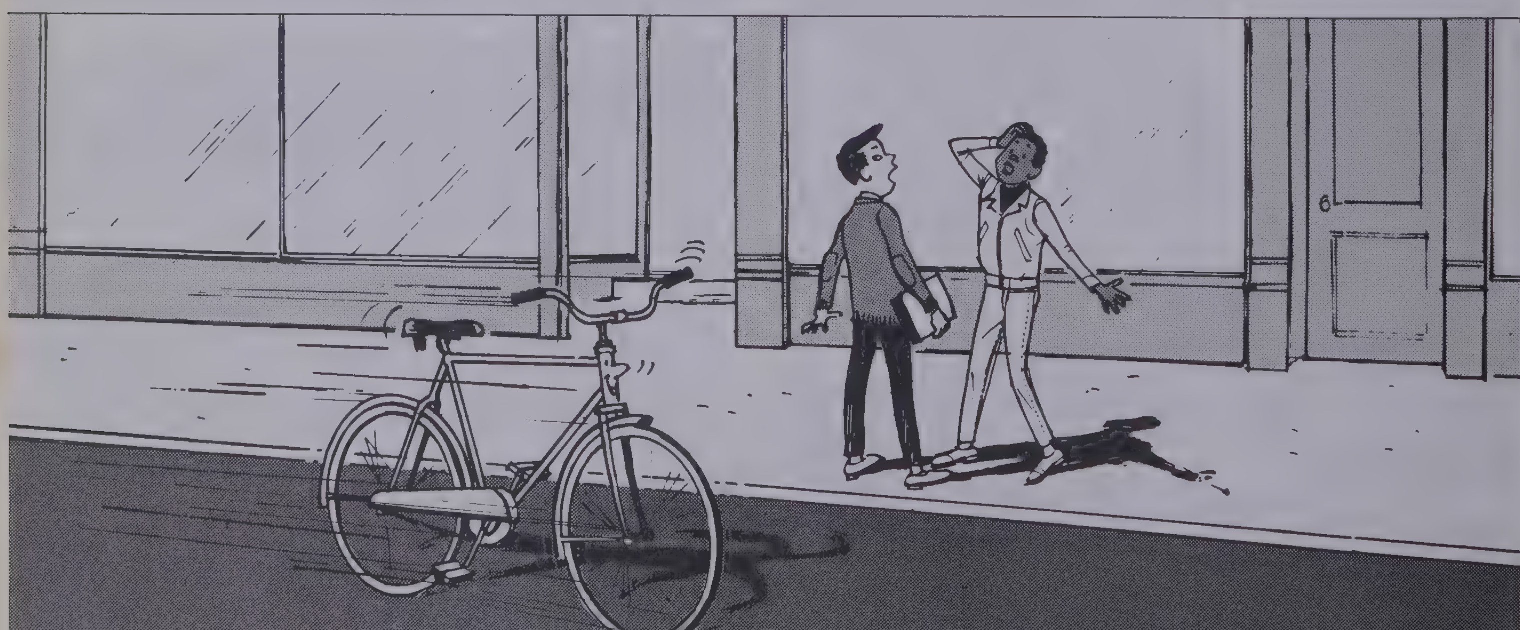
Laurence Fink

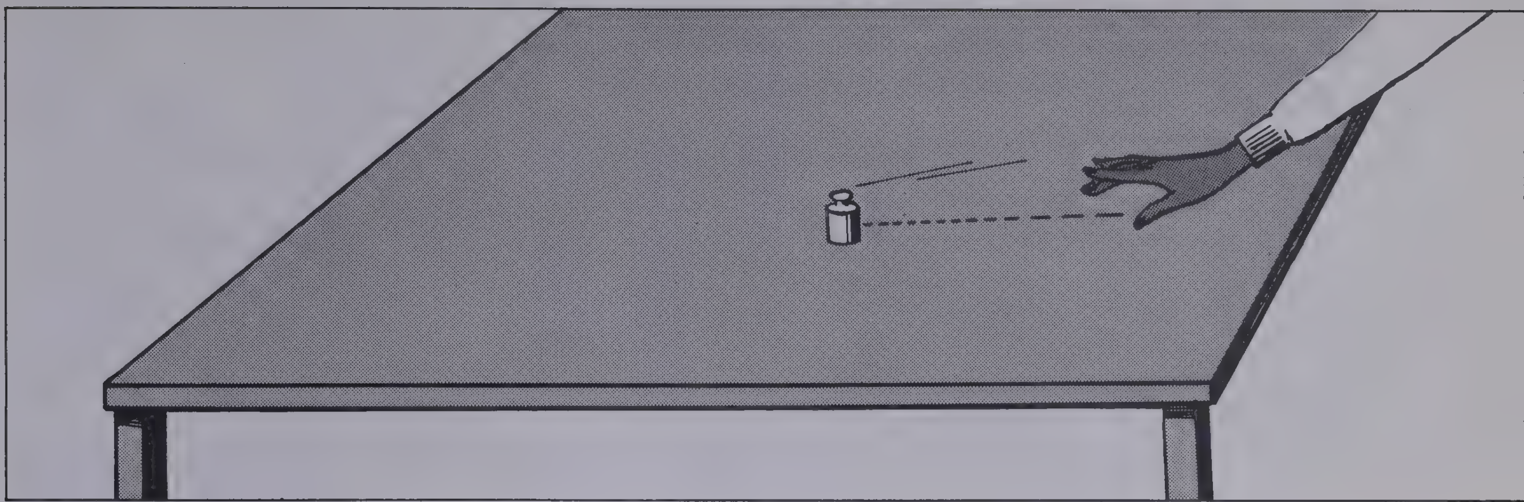
Kosti Ruohomaa from Black Star

The job of the scientist is to find patterns and order in the universe. We know what the universe is made of, but there is more to it than that. Understanding matter is only part of the story.

Everything around us is moving. The air rushing by as wind, cars zipping up and down the street, the moon wandering across the sky—wherever we look there is action. So now we come down to the important question: what causes the action?

We have a clue. A ball lying on the ground doesn't get up and fly through the air by itself. A bicycle doesn't suddenly go whizzing down the street unaided. Things don't start moving about without help. Something else has to get into the act.





A. PUT SOME MUSCLE IN IT

1. What happens to things to make them move?

2. Slide a weight along the table. What did you do to make it move?

3. What is a general word to cover either a push or a pull?

4. Pick up a weight from the floor. What did you apply to the weight?

5. If you lift weights for half an hour, what do you think you have done?

A scientist defines work as a force acting over a distance.

6. Is pushing a stalled car work? Explain.

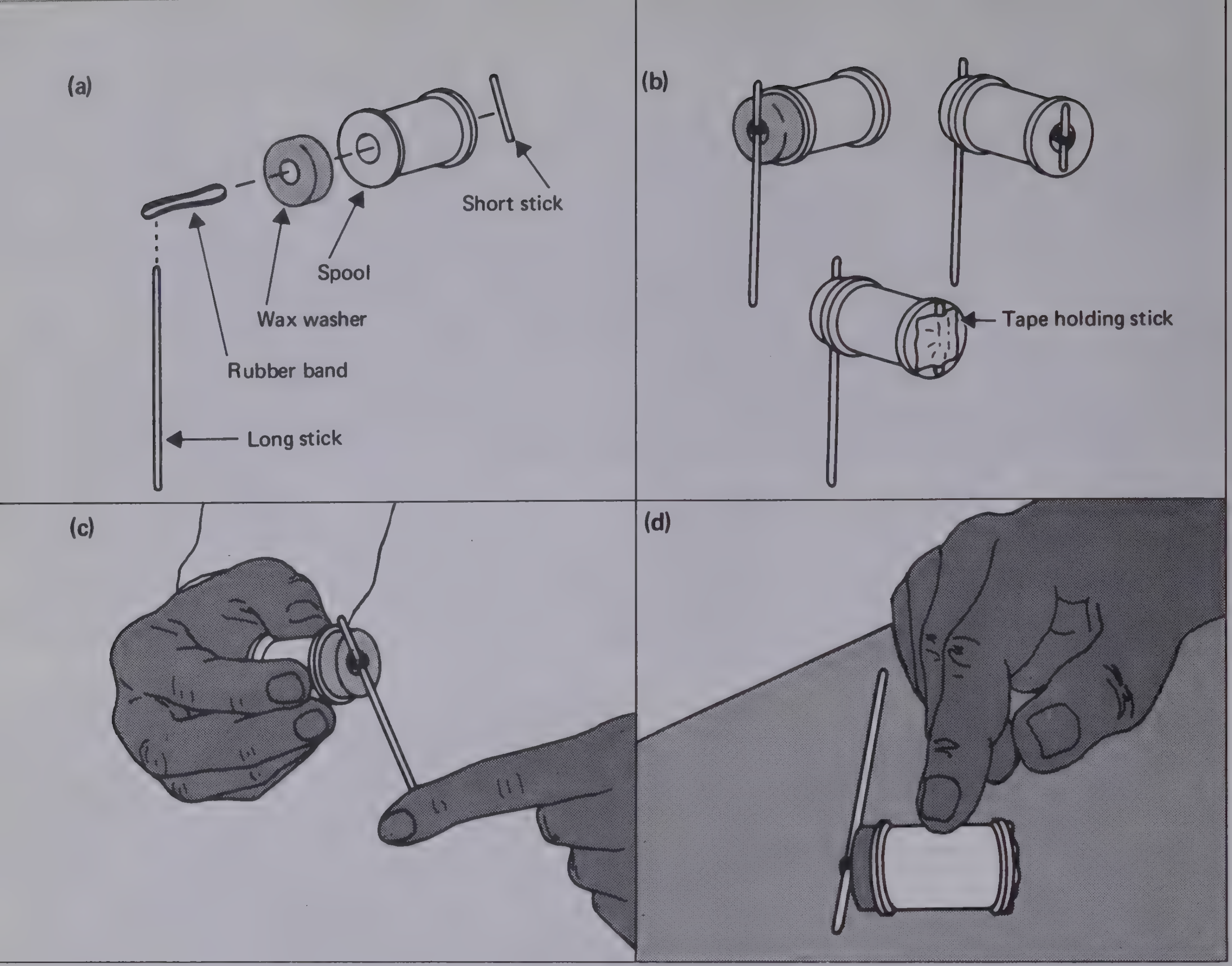
7. Is pushing against the side of a building work if the building doesn't move? Explain.

B. WORK IS STORED IN BOXES?

We have agreed on what we mean by work, but there is more to it. What happens to work when it's not working? Where was the work before you lifted the weight?

8. To put it another way: can the ability to do work be stored?

©Mobil Oil Corp.



Pass a rubber band through a spool and wax washer. Slip a short piece of matchstick through the spool end of the rubber band. Tape it down so that it can't move.

Measure off another piece of matchstick three times the diameter of the spool. Slip it through the end of the rubber band that is sticking out of the wax washer. Now twist it around in a circle to wind up the rubber band.

9. Is winding it up work? Explain.

10. Wind up the rubber band about 30 turns. Set the spool down on the table. What happens?

11. How is work being done?

12. Where is this force coming from?

You did work to wind up the rubber band. The rubber band did work when it made the spool move along the table.

13. First the rubber band was wound up, and a little later the spool started to move. What happened to the work between those two actions?


U.S. Forest Service

C. WORK UP A SWEAT

When you finish a job, is that the end of your work? For instance, while you are pulling a saw through a log a lot of work is done, moving the saw back and forth. The question is, what happens to the work?

14. What is your prediction?

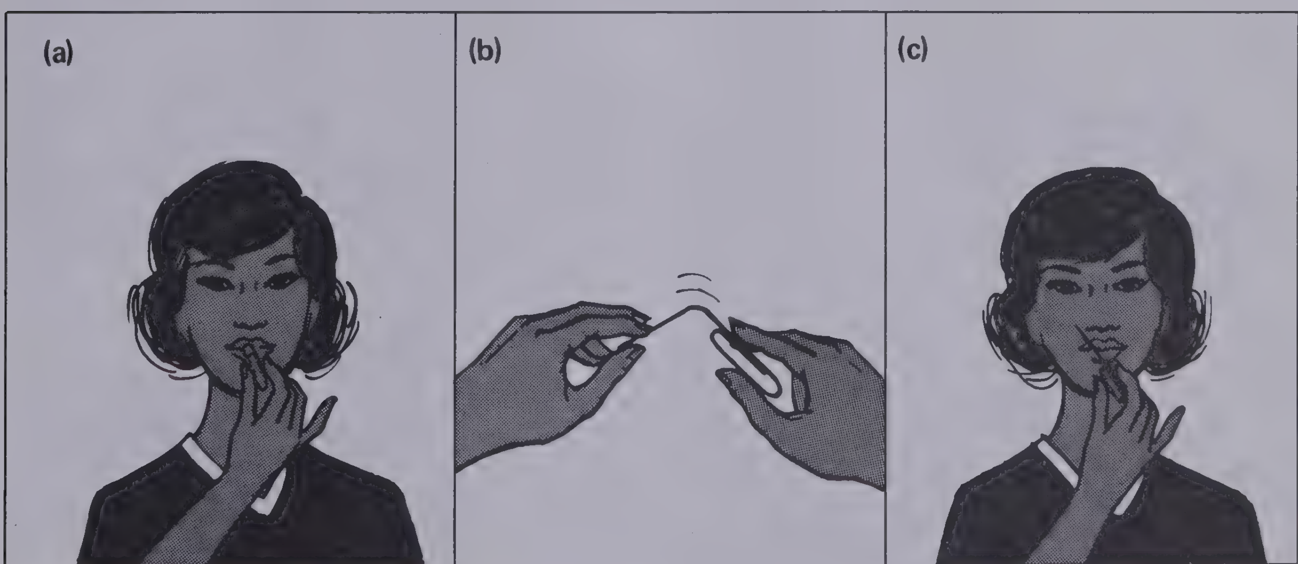
15. Take a paper clip. Hold one of the rounded ends to your lips a moment. Now quickly straighten out that rounded end. Hold that place to your lips again. What do you notice?

16. Have you done work? Explain.

17. How does a saw blade feel just after it has been used?

18. If you touch a nail just after pounding it, how does it feel?

19. What does work seem to turn into sooner or later?



We have come a long way in this investigation. We have discovered that force is a push or a pull. (You can feel the push or pull even with magnets that are not touching.) And we now know what is meant by work.

CONCEPT SUMMARY. (A push or a pull is called a *force*. Tell what work is considered to be.)

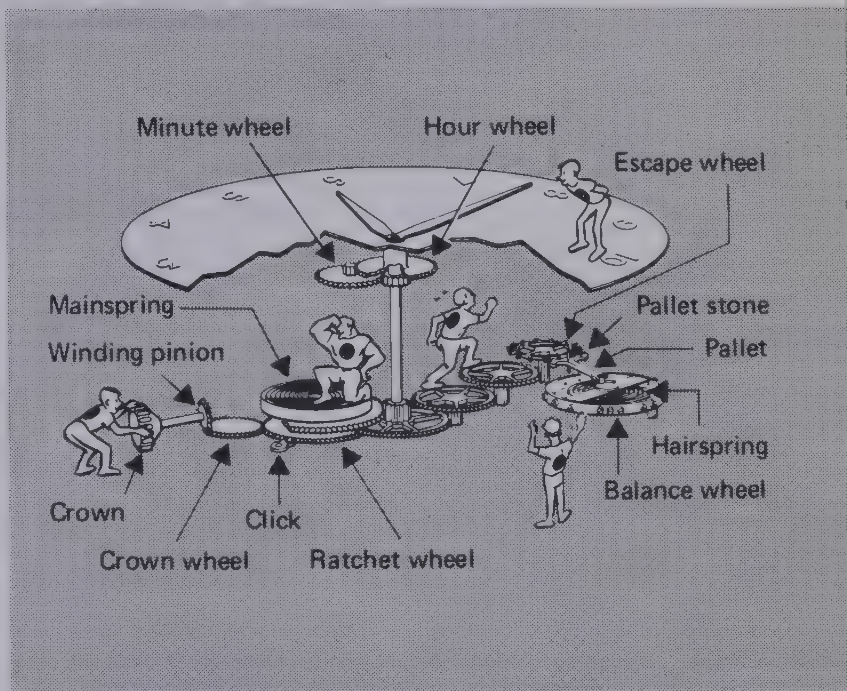
Henry Monroe from dpi

Investigation 2

It's Always Work

It is the work done on the ball that sends it down the alley. The ball passes work along when it sends the pins flying. It takes work to spin the wheels of a car, bulldoze out a highway, or turn the hands of your wristwatch. In all of these examples, something is moved.

American Machine & Foundry Co.



Caterpillar Tractor Co.

LaCrosse Tribune Photo

But is motion the only result of work? You are reading this page by using light. The light may come from the sun, a light bulb, or a fluorescent tube. Light also comes from gas flames, fireworks, and the picture tube of your TV set.

A. SEE THE LIGHT

1. What do most of the things that give light also produce?

2. What did you discover in Investigation 1 about heat and work?

Here we have what the scientist looks for: a pattern in nature. There seems to be a relationship among the three things we've been discussing.

3. What is your prediction about this relationship?

As has been happening all along, observations have led to questions. The questions have produced a prediction and the next step is to test it.

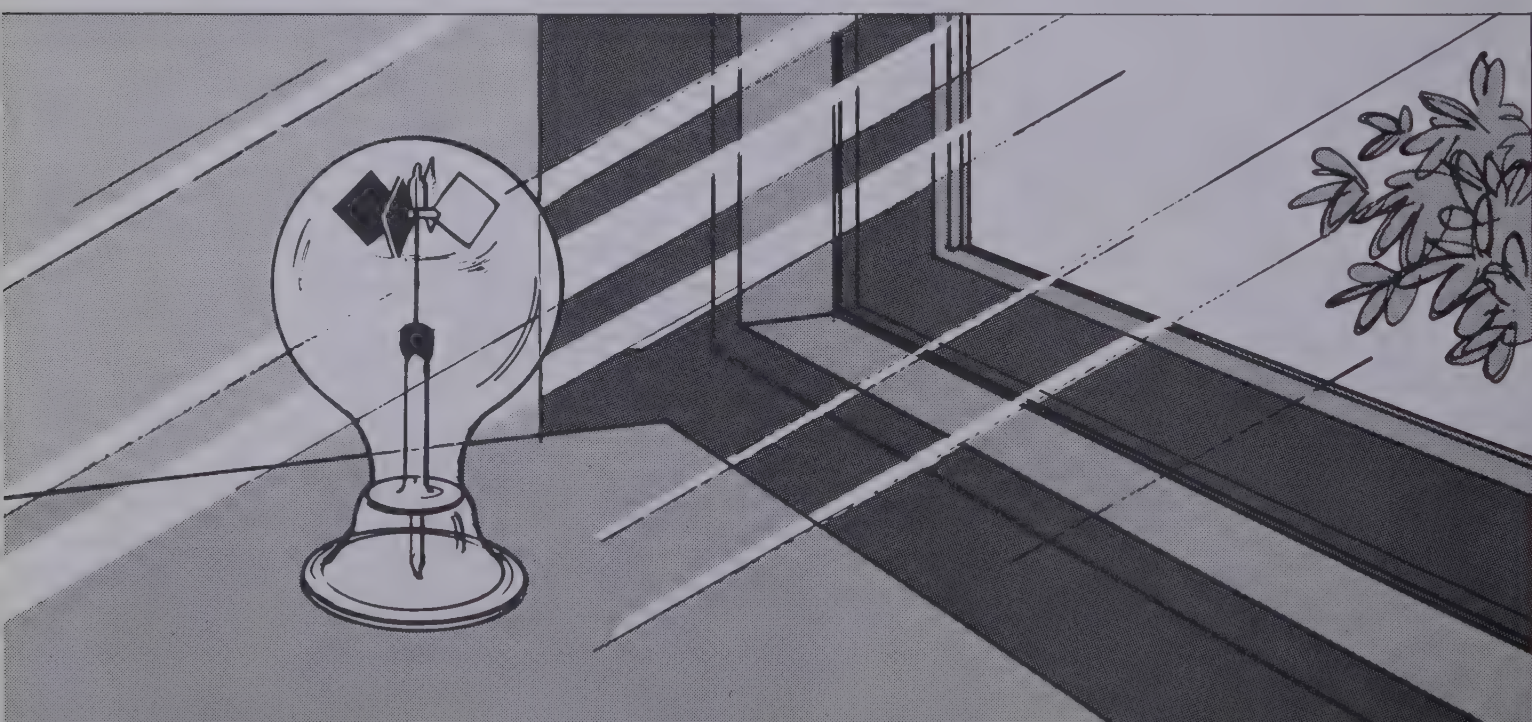
Let's start with what we see with: light. In fact, we can't see without it.

A radiometer is a set of silver and black metal fins balanced on a pin. Place one in sunlight or near a very bright light.

4. What happens?

5. What happens when you cut off the light?

6. How does this data show that light and work are related?



B. FEEL THE HEAT

In the last investigation you bent a paper clip quickly and got heat. It was a case of movement giving heat. What about the other way around: will heat give movement?

7. Pack paper towels soaked in hot water all around the radiometer. Leave a little hole to see through. What happens?

8. Remove the hot towels. What happens?

9. How does this data show that heat and work are related?

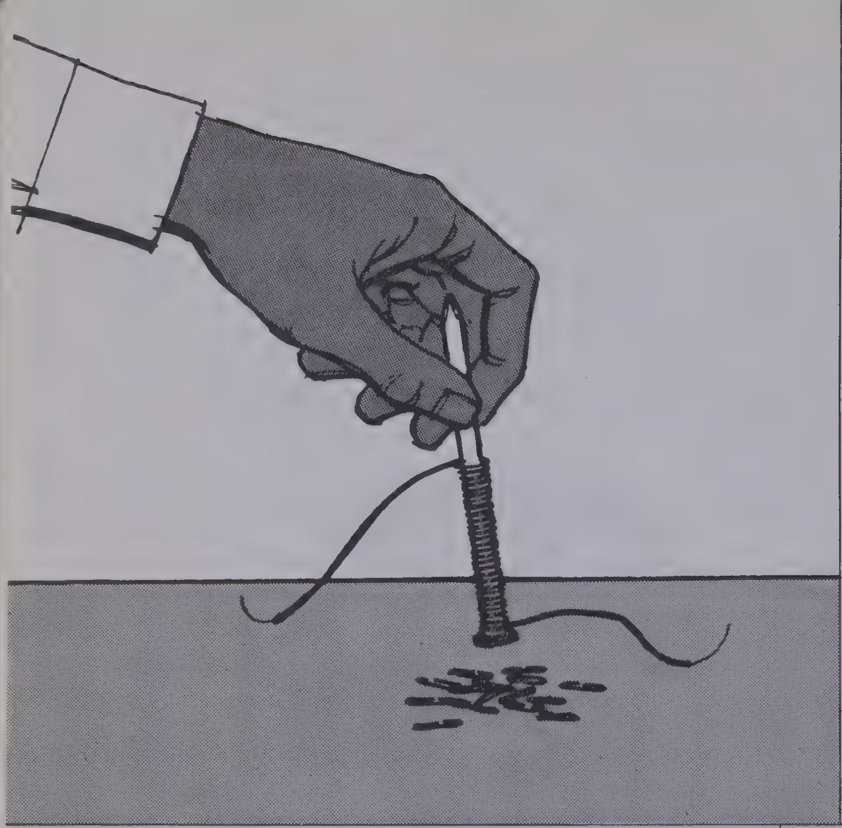
10. If a car is left out in bright sunlight, it becomes hot. A heated piece of metal, such as a light bulb filament, will give off light. What do these clues tell you?

C. TAKE CHARGE

So work, light, and heat are all related to each other. However, don't imagine we're through. There's another step. Light and heat come from some place.

11. What do we use in our homes to produce light and some heat?

American Electric Power

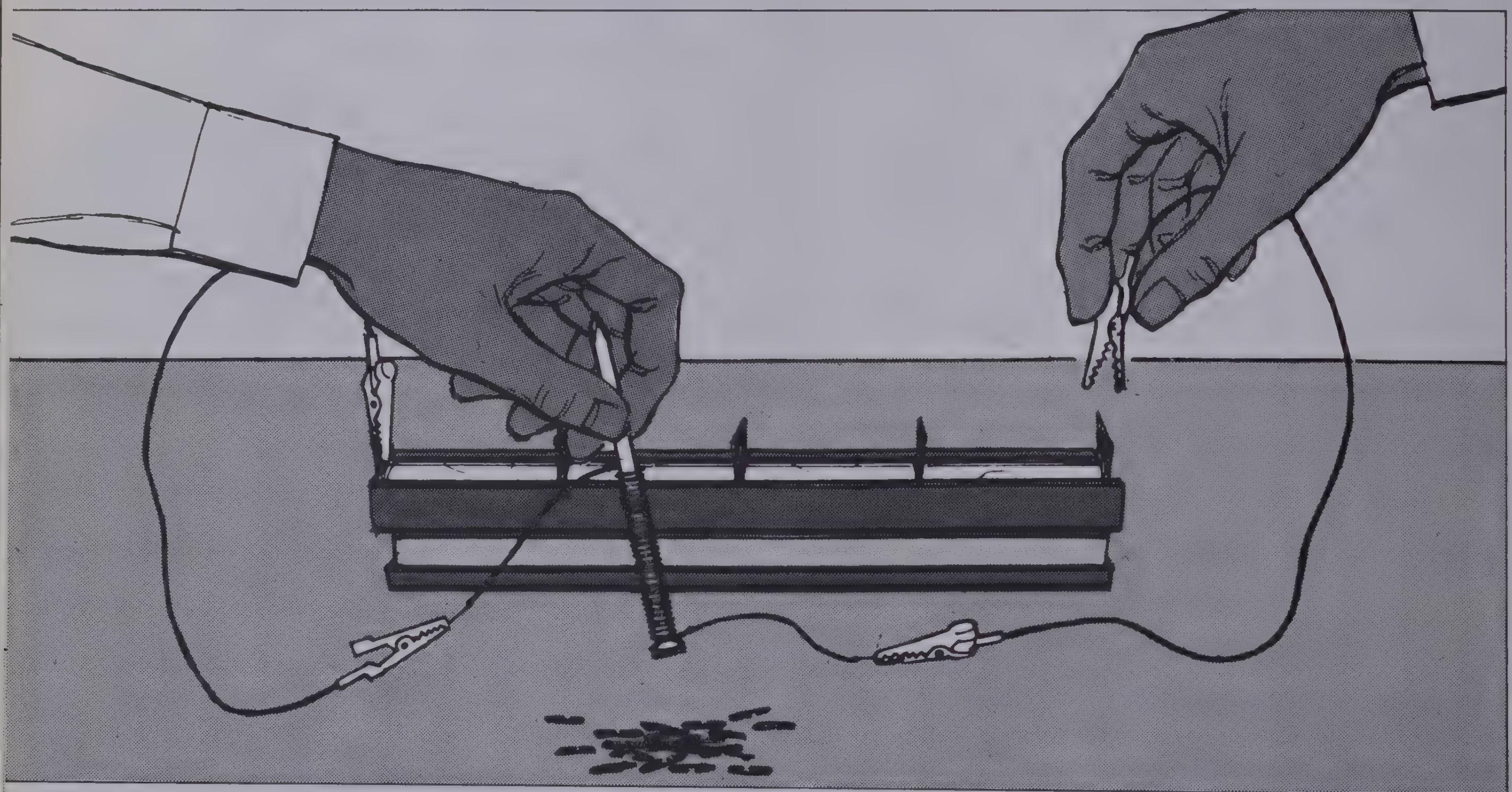


Now let's test to see if electricity has any connection with work.

12. Carefully wrap 20 feet of thin copper wire around your 6 inch long spike. Sandpaper the enamel coating off of the ends of the wire. Hold this coil above a pile of small bits of metal, such as paper clips. What happens?

13. Connect the ends of the coil to the terminals of a battery pack and hold the nail above the bits of iron again. What happens this time?

14. Has work been done? Explain.



15. What happens to a light bulb when it is turned on—apart from the fact that it gives light?

16. What does the data of this investigation show about electricity, heat, and light?

17. How did your prediction in question 3 turn out?

CONCEPT SUMMARY.

Investigation 3

There Must Be an Easier Way

Let's look over what we know about work. Whether a champion pool player is sinking the eight-ball or a jackhammer is cutting through rock, work is being done. We know this because in each case force is acting over a distance.

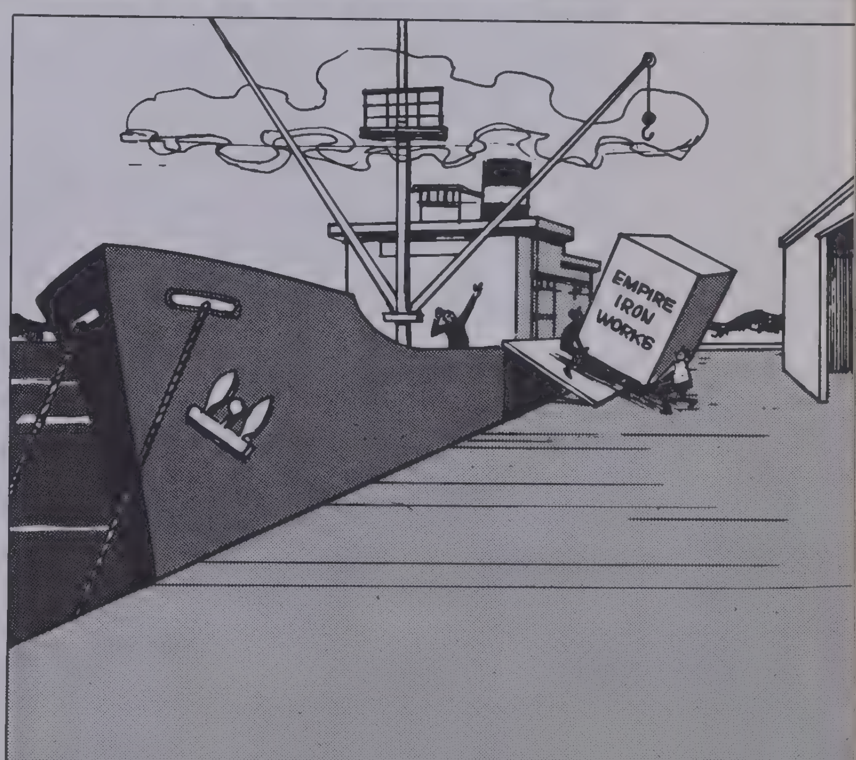

Wide World Photo

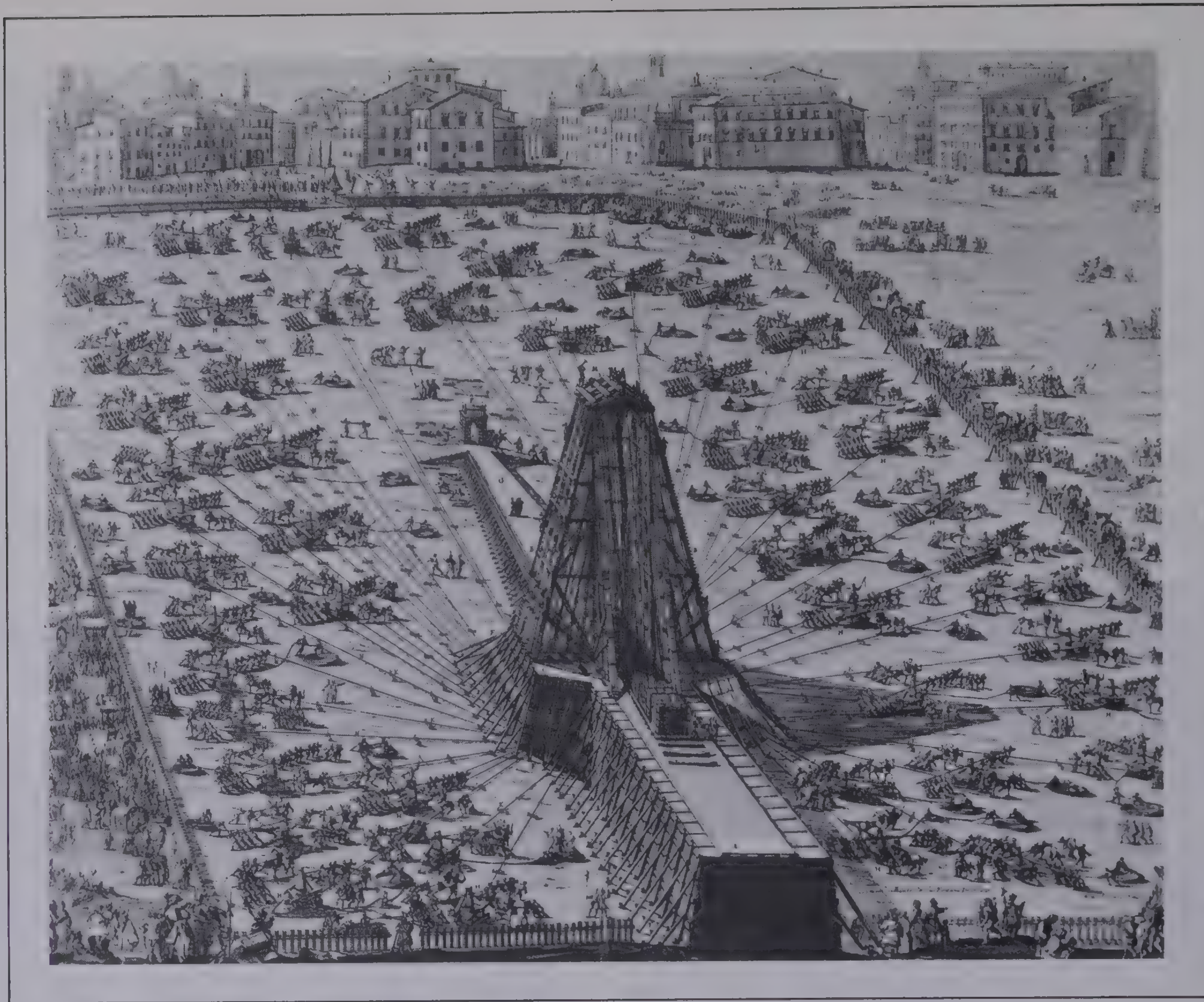

Sam Falk from Monkmeyer


Frank Salmo from Black Star

Work takes many forms. The lights go on when you flip the switch. Every now and then a click and a humming sound tell you the refrigerator is working. The toaster gets busy every morning. What about riding a bicycle? Now muscles, not electricity, are supplying the force. This brings up a problem.

When you have to carry a heavy weight up a ramp, or unscrew the lid on a jar of jam, the awful truth comes out: sometimes muscles are not enough. Muscles need help.





Moving an obelisk in Rome in 1586. Over 900 men and 40 horses were used to work the blocks and tackles

A. HAUL AWAY, MEN

1. What general name is used for devices that can lift things too heavy to lift by hand?

2. It is sometimes said that machines make men's work easier. Is there any difference between doing easier work and doing less work? Explain.

We will investigate a simple machine for lifting things. Pulleys have been used at least since the time of Archimedes, our friend from ancient Greece (Idea 2, Investigation 1).

Tie one end of a string to a support hanging over your desk. Pass the other end through a pulley. Attach this end to the hook on your spring balance. Attach a weight to the hook on the pulley. From now on we will call this weight the "load." Raise the pulley and the load by pulling up slowly on the top end of the spring balance.

3. How much force does it take to raise the pulley with the load attached?

Part of the force you just used was lifting the pulley. The rest of it was lifting the load.

Remove the load and slowly raise just the pulley by pulling up on the top end of the spring balance.

4. How much force does it take to raise just the pulley?

5. With the load attached to the pulley, what part of the force was lifting just the load? Hint: Check again your answers to questions 3 and 4.

Remove the load and the balance from the pulley. Attach the load to the balance. Slowly pull up on the top of the balance.

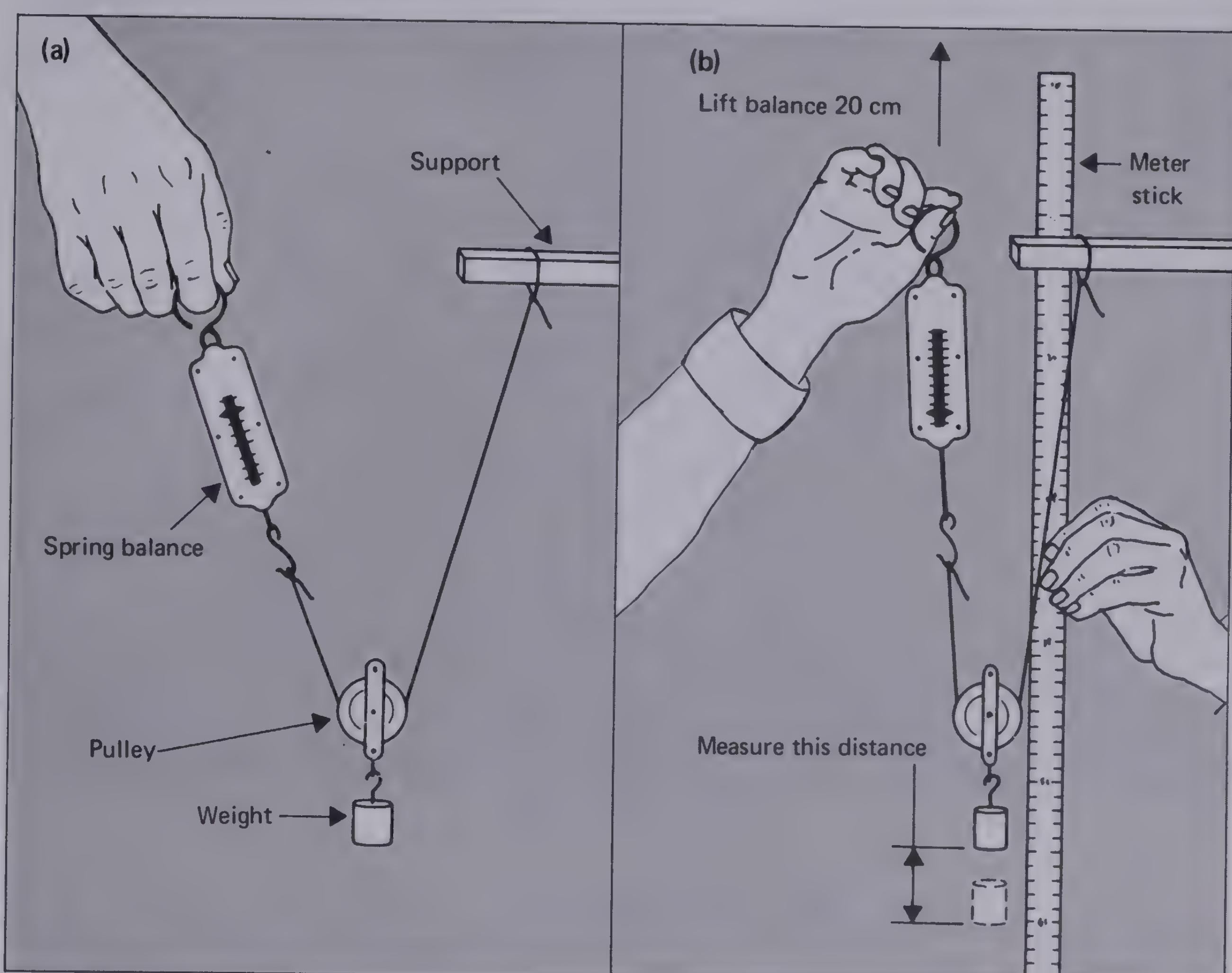
6. How much force is needed to raise the load when not using the pulley?

You now have measurements of the forces: the force needed to raise the load when helped by the pulley, and the force needed to raise it without the pulley.

7. Compare these two forces by dividing the lifting force without the pulley by the lifting force with the pulley (round off your answer to the nearest whole number). What do you get?

Now we will investigate distances. Again attach the load and spring balance to the pulley. Measure how far up the load moves when you lift your hand 20 cm.

8. How far does the load move?



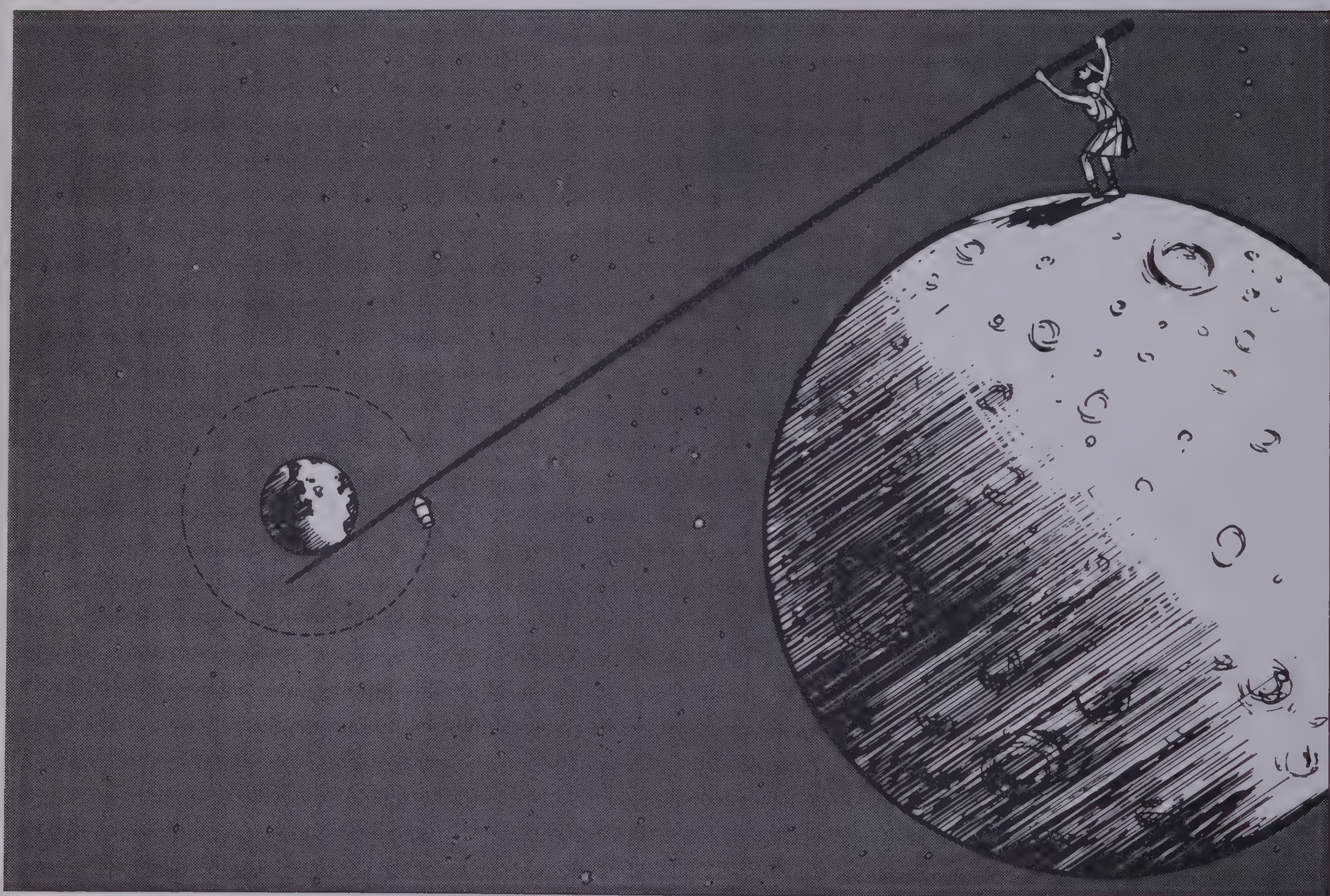
We now have two distances: the distance the force (your hand) moves, and the distance the load moves.

9. Compare these two distances by dividing the distance your hand moves by the distance the load moves (round off your answer to the nearest whole number). What do you get?

10. Is the force comparison of question 7 larger than, smaller than, or the same as the distance comparison of question 9?

B. SEESAW, MARGERY DAW

Pulleys are useful, but they are not the machine we use most often. Jack up the car to change a tire, pry the lid from a paint can, or pull out a nail with a claw hammer, and a different machine is in use. Archimedes used to say: "Give me a place to stand, and I will move the earth."



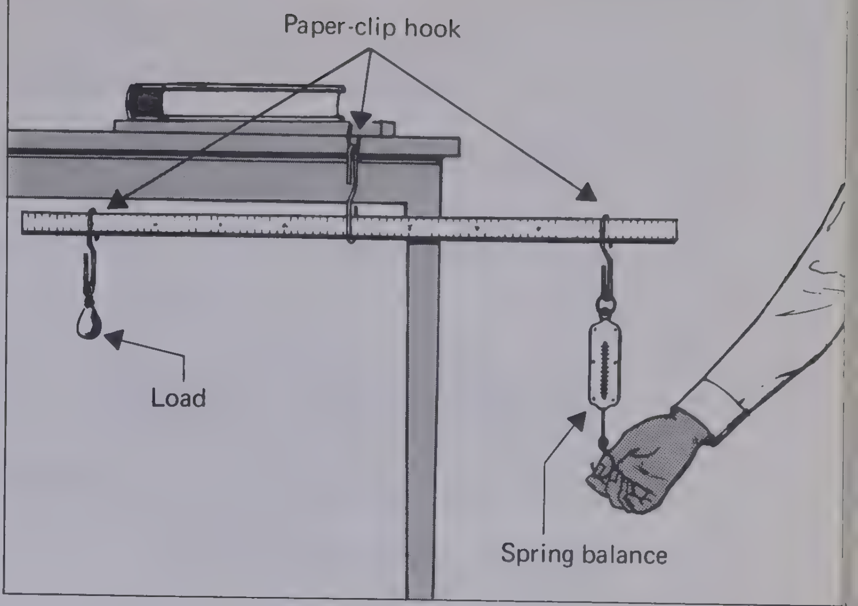
11. Where might he have stood?

12. What else would Archimedes have needed to move the earth if an Apollo mission could have taken him there?

Balance your meter stick on a paper-clip hook attached to the table.

Hang a paper-clip hook at 10 cm and another at 90 cm, and get the meter stick in balance again.

Hang the load you used with the pulley on the left-hand hook. Hang the spring balance upright on the right-hand hook. Pull the hook at the bottom of the spring balance to balance the meter stick.



13. What is the reading on the spring balance?

14. Weigh your spring balance on the spring balance of some nearby students. The weight of the spring balance pulls down on the meter stick in addition to the pull you give with your fingers. Therefore, add the balance's weight to your answer to question 13 to find the total force balancing the load.

15. How does this compare with the actual weight of the load?

16. Now move the load in so that it is only 20 cm from the balance point. Keep the spring balance still at 90 cm. Take the reading on the spring balance and add the weight of the balance. Record.

17. Does your answer to the question above amount to just about one-half, one-third, or one-fourth of the actual weight of the load?

18. Compare the distances of the two objects from the balance point. What is the ratio of their distances?

19. What do you predict would be the force needed if the spring balance were three times as far from the balance point as the load?

All right, so let's find out. Go ahead and do it. Don't forget to add the weight of the spring balance which helps your muscle force to make the total force supporting the load.

20. What was your total reading?

21. About what fraction is this of the weight of the load?

22. If the load stays at the same distance and you keep moving the spring balance farther away, does the force needed become more or less?

23. If the spring balance stays in the same place and the load keeps moving farther out, will the force needed become more or less?

24. What is the simple machine you have just been investigating called?

25. What does it do for you?

26. In other words, a lever lets you save force, but you must apply the force over a greater ___?___

A crowbar is a good example of a lever. It lets you pry up heavy rocks by using your muscle force at the far end with a support near the rock to act as a balance point.

27. Name some other tools and machines that use levers.

CONCEPT SUMMARY.

Tim Sheehan from Black Star

Investigation 4

Is This on the Level?

Now we know what we mean by work. We can even find ways of controlling how much force we have to use to do work. But we are not finished. Levers, pulleys, and their relatives the wheels and gears, are not the only machines that have been around a long time.

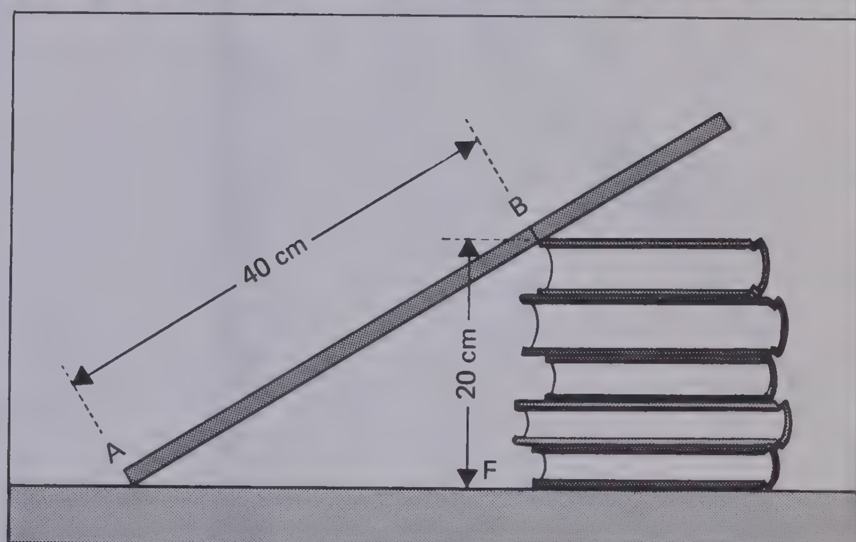
There is one machine which may have been used to build the pyramids. Let's see how it works.

A. IT'S ALL IN THE ANGLES

The Bettmann Archive, Inc.

1. Weigh the little car together with any weight your teacher has you attach to it. What is the total weight?

Put your board the way it is shown in the picture. Put it so the distance from A to B is 40 cm and the height from F to B is 20 cm.



Attach the spring balance to the car and pull the car up the board with a slow, steady pull.

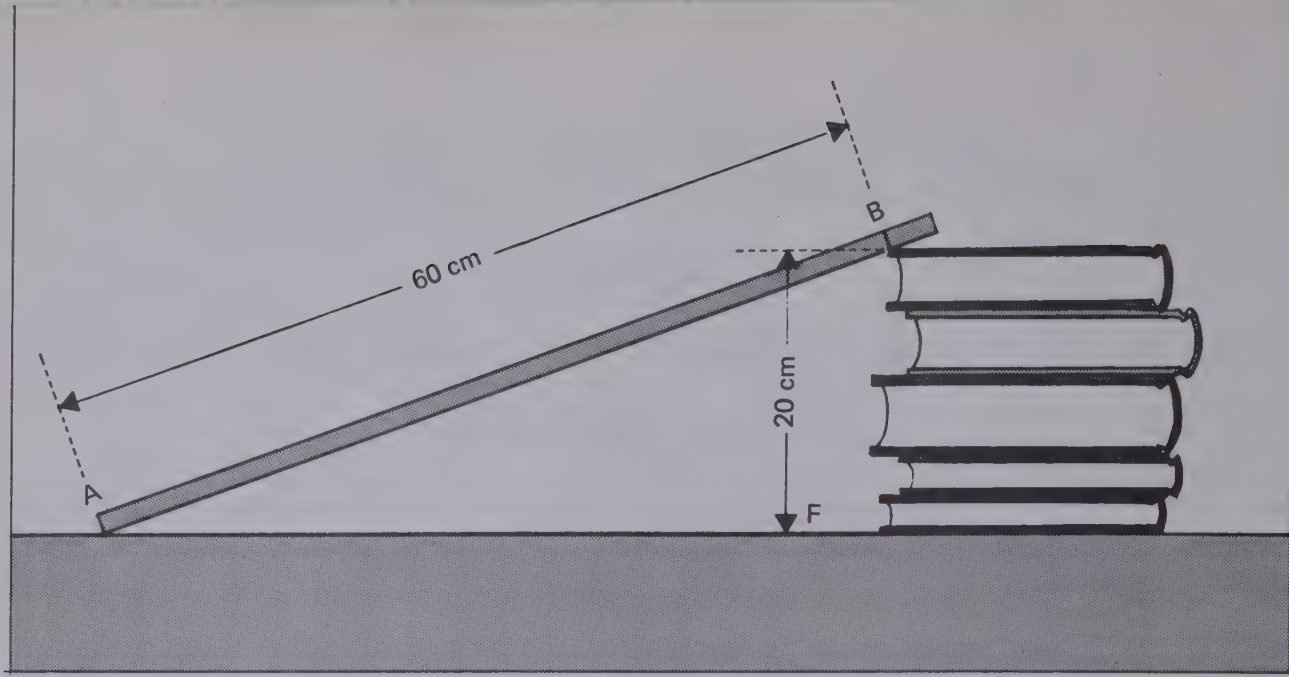
2. How much force do you have to pull with?

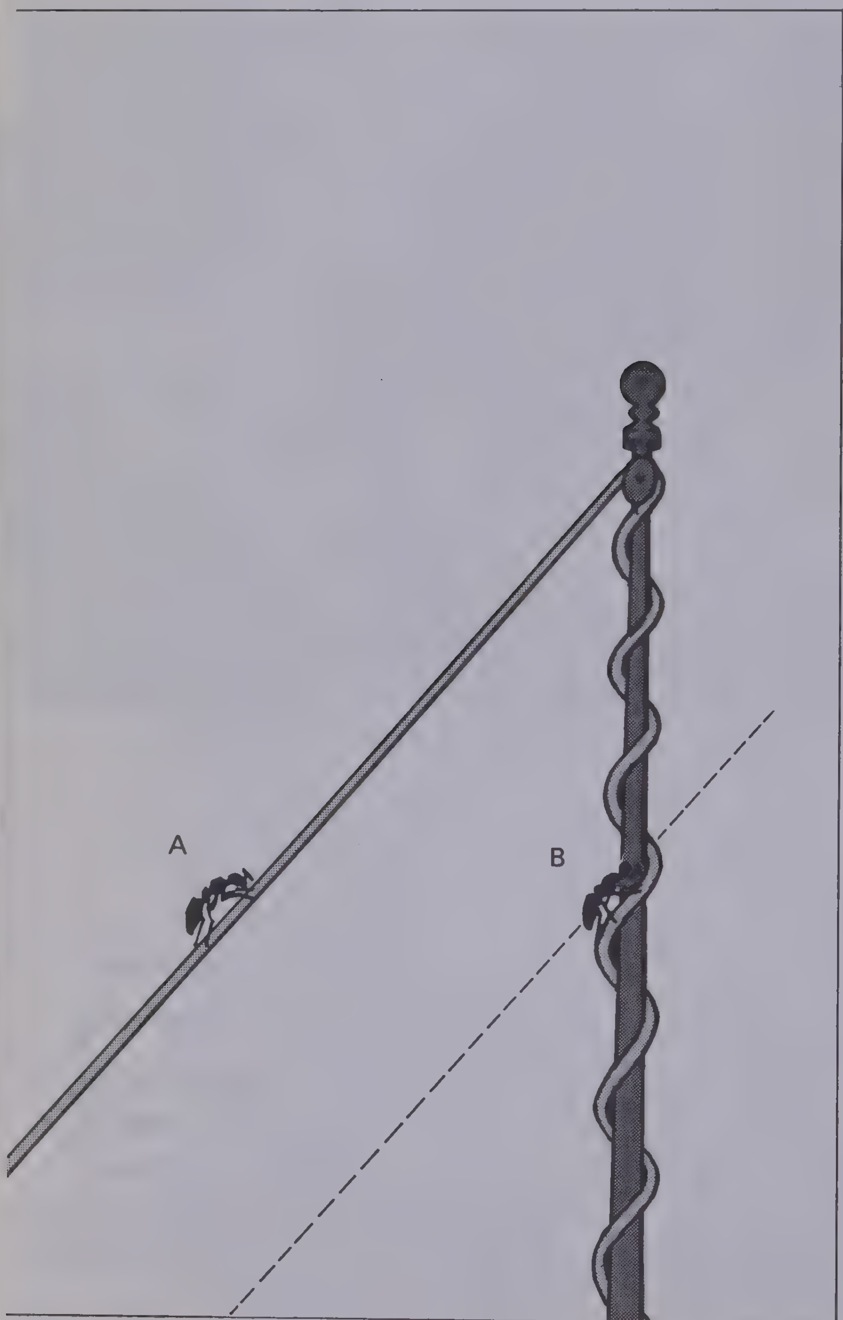
3. Compare the car's weight and the pulling force by dividing the weight by the pulling force.

4. Compare the distances AB and BF by dividing AB by BF.

5. Are your answers to questions 3 and 4 about the same, or is your answer to "3" much larger or much smaller than to "4"?

Change the way the board is leaning so that distance AB is 60 cm, and the height, BF, stays the same.





6. Is the board more steep or less steep than it was before?

7. Make a guess: To pull the car up, will you have to pull with a larger force or a smaller force than you did before?

8. Make a prediction: How much pulling force do you think your spring balance will read when you pull the car up with the board in the new position?

9. Attach the balance and pull the car up with a slow, steady pull. How much pulling force does your balance say?

10. To get an idea about how good your prediction was, look at your answers to "8" and "9." Subtract the smaller answer from the larger. What do you get when you subtract?

11. Explain why it is easier to pull the car up the board than it is to lift it straight up.

12. The picture shows two bugs walking up a flagpole rope. Is bug A walking up an inclined plane?

13. Is bug B walking up an inclined plane?

14. Have you ever seen any inclined planes besides boards? If you have, describe them.

B. WHO GETS TO WATCH THE MACHINE?

Work is made easier by machines, but people still have to stay around to run the machines—or do they? Something is changing about the way that machines are run. It is happening in factories, oil refineries, power plants, and on ships.

15. What is it that is changing?

In Table No. 1 are some data on a food-processing plant that modernized its equipment. (Maintenance and technical workers are considered skilled.)


Taystee Bread

TABLE NO. 1

DISTRIBUTION OF WORKERS IN A FOOD-PROCESSING PLANT

Type of Work	Percent of Workers	
	Before Modernization	After Modernization
Direct Production		
Skilled	3.7	20.4
Semiskilled	22.5	20.9
Unskilled	51.7	10.5
Maintenance	21.4	36.1
Technical	0.7	12.1

16. How did the percent of unskilled workers change?

17. How did the percent of skilled workers change?

18. Which group would you expect to have had the most education?

19. Which group would you expect to have the most pay?

TABLE NO. 2

DISTRIBUTION OF UNEMPLOYMENT BY EDUCATION

Years of School Completed	Unemployment in Percent			
	1950	1957	1959	1962
9-11	6.9	4.7	8.1	7.8
12	4.6	3.0	4.9	4.8
16	2.2	0.6	1.4	1.4

20. In conclusion, how do simple machines affect the amount of force used to do work?

21. How do simple machines affect the amount of work done?

CONCEPT SUMMARY.

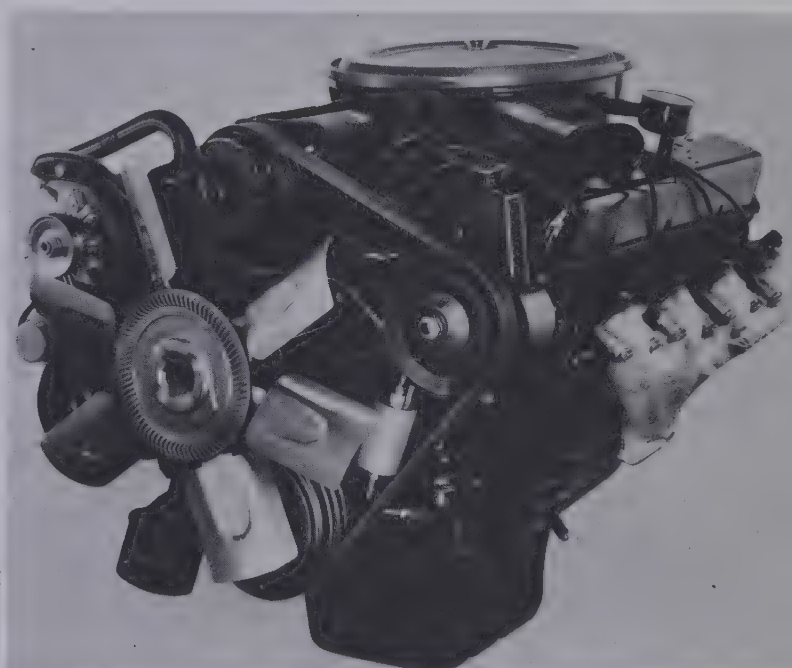
Investigation 5

Heat Makes Work and Work Makes Heat and–

We know that a force acting over a distance does work. We also have some ideas about the forms work may take, such as heat, light, and electricity. We have learned how simple machines may be used to make work easier.

The word *machine* may make you think of a fast-moving car, a roaring jet, or a noisy motorcycle. With a good imagination you can even smell the exhaust.

Solo Industries



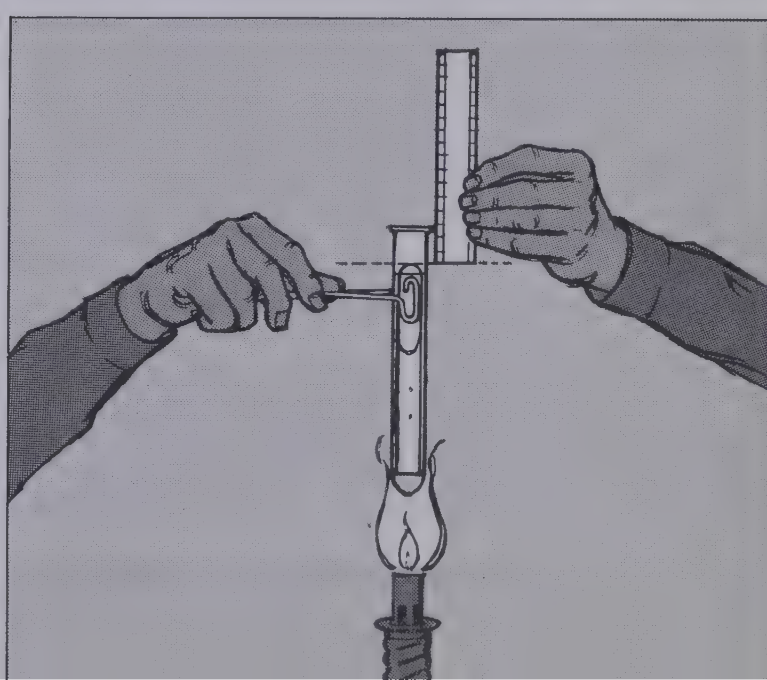
General Motors

This brings up an interesting point. Many machines burn fuel. Now a can of gas doesn't do anything by itself. A gallon of diesel oil or jet fuel doesn't do much all alone, either.

A. ON THE HOT SPOT

1. What happens to fuel in machines?

2. How do you think we get motion from fuel?



You can start testing ideas with simple equipment. Most engines have round spaces inside called *cylinders.* They are shaped like tubes. You can use two flame-proof test tubes to see how they work.

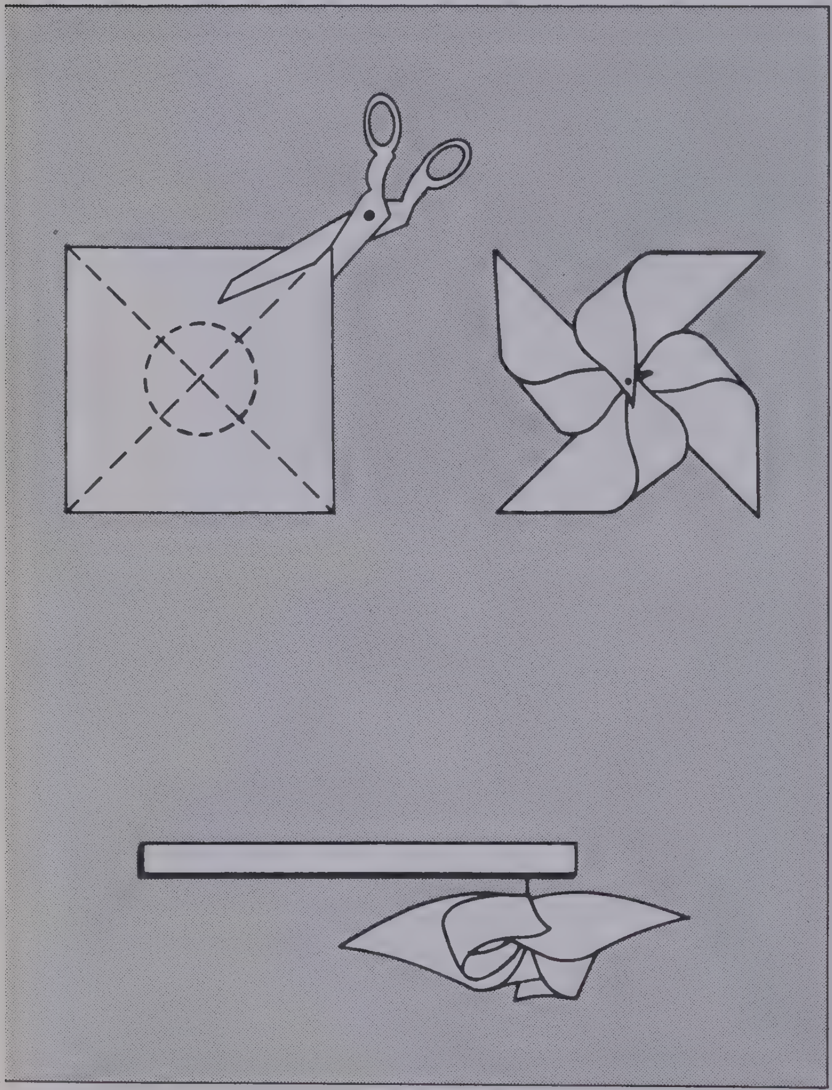
Fill both test tubes about one-third full of water. Quickly slide the smaller test tube upside down inside the larger one. It should just barely float. Measure the distance from the upper end of the smaller tube to the lip of the larger tube. Note whether the end of the smaller is above or below the lip of the larger.

3. Record this distance.

Use a test tube clamp to hold the test tube over a flame for about a minute. (You don't need to boil the water.)

4. What happens?

Measure the distance from the end of the small test tube to the lip of the large one again. Note whether the end of the small tube is above or below the lip of the large tube.



5. Record the total distance that the small tube rose.

6. If you have just recorded that the test tube moved, what has been done?

7. What kind of force produced this motion?

8. Explain how this was like what happens when gasoline burns in an automobile engine.

B. ROUND AND ROUND

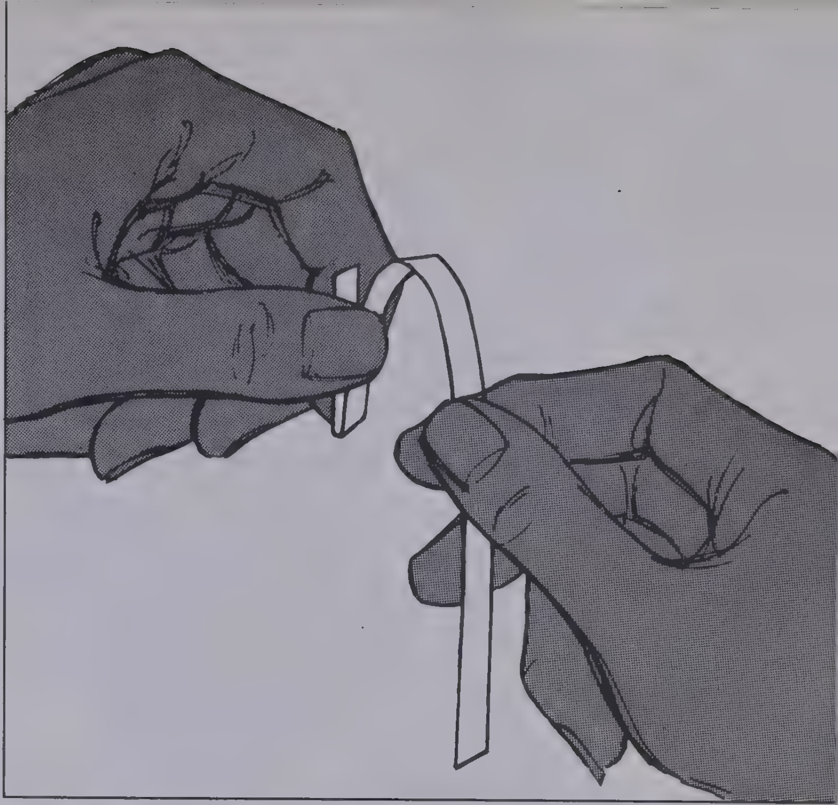
Take a sheet of paper and cut one end off so that the paper is square. Locate the center of the square by drawing 2 diagonal lines from the corners. The lines cross at the center of the square.

Using a compass, draw a circle 1/3 of the way from the center to the corners. Cut a slit from each corner to the circle. Use a stick and a pin to make a pinwheel. (Two ice-cream sticks taped together lengthwise make a good stick.)

Hold the pinwheel over a burner, high enough so that it does not catch fire.

9. What happens?

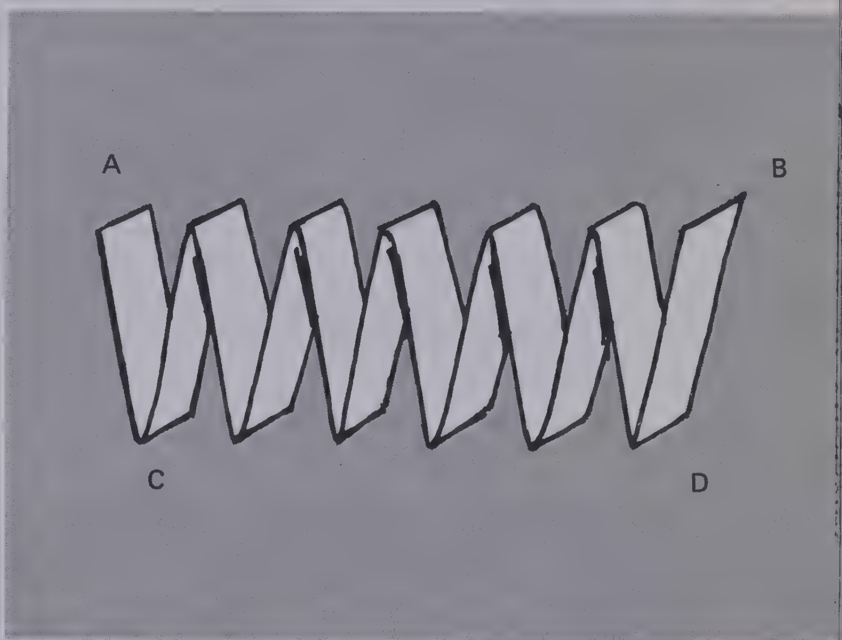
10. What did the heat energy from the burner do?



C. FASTER AND FASTER

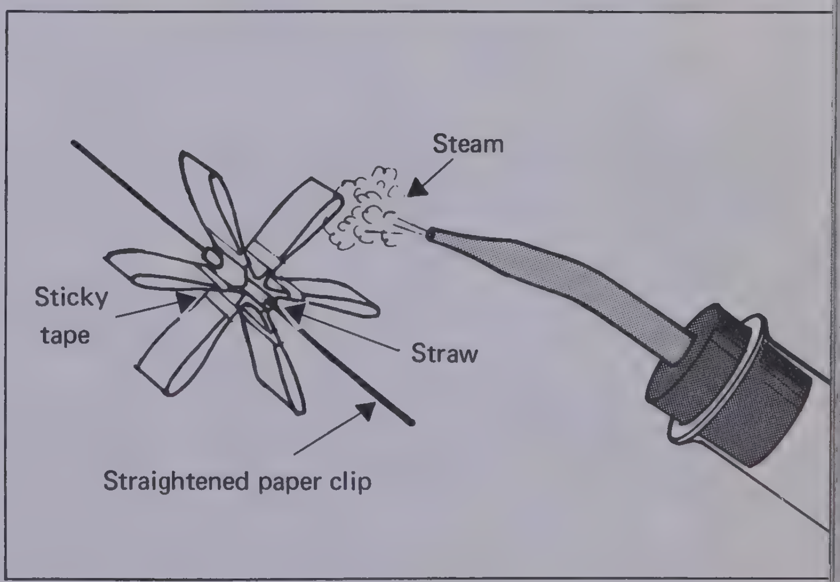
Fold over the strip of cardboard 23 mm from the end. Repeat this folding procedure over the entire length of the strip, and cut off any small piece left on the end.

Place the strip as shown in the picture. Swing end A down and around until A is next to B, and C is next to D. Tape A and B together. Run a thin strip of tape around each of the six points of the star.



Insert through the middle a piece of drinking straw 3/4 of an inch long. A straightened paper clip put through the straw completes the construction of your pinwheel.

Fill a test tube about one-third full of water. Use a few boiling chips. Put in the stopper with the bent glass tube through it. Place the test tube over a burner. When the water boils, direct the steam jet against the pinwheel.



11. What happens?

12. What did the steam's heat energy do?

13. What kind of engine works on this system?

14. How does this explain the function of the fuel in a turbojet engine?

15. What happened to make the test tube rise?

16. What happened to make the pinwheel turn?

17. What seems to be the general method of converting heat to motion in engines?

D. ALWAYS WE HAVE COMPLICATIONS

Engines that convert heat to work have been very successful. Table No. 1 shows just how successful.

Draw Graph No. 1 using the data in Table No. 1. (Make it a line graph.) Continue your last straight-line segment as a dotted line to show predictions for future years.

TABLE NO. 1

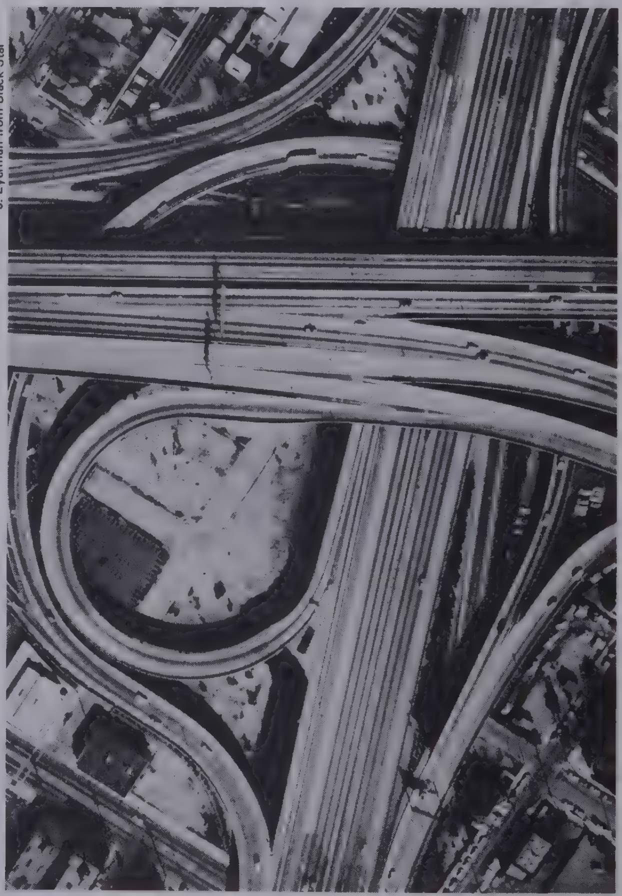
TOTAL MOTOR VEHICLES IN THE UNITED STATES

Year	1950	1955	1960	1965	1970
Vehicles in Millions	49.3	62.9	73.9	90.4	106.0

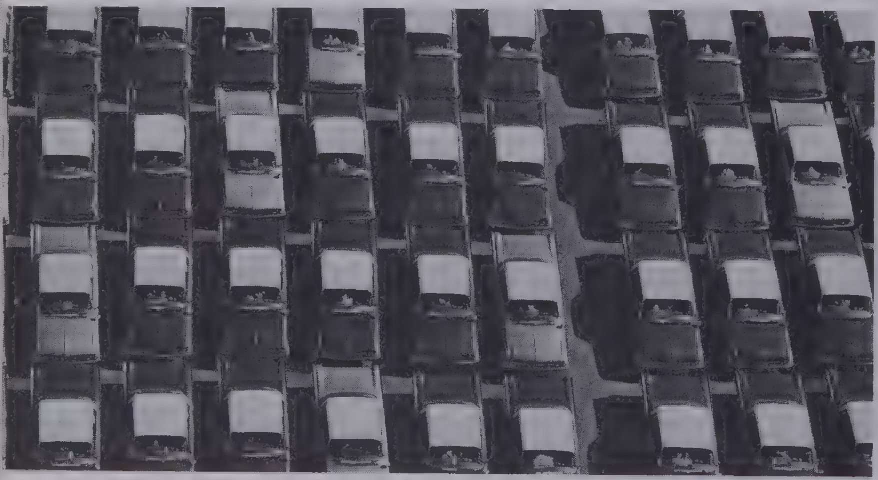
18. About how many vehicles does the graph predict for 1975?

19. For 1980?

In 1966 there were over ten million vehicles in the state of California. One out of every fifty square miles of surface in that state is paved. The number of vehicles in California goes up by about a half-million a year.

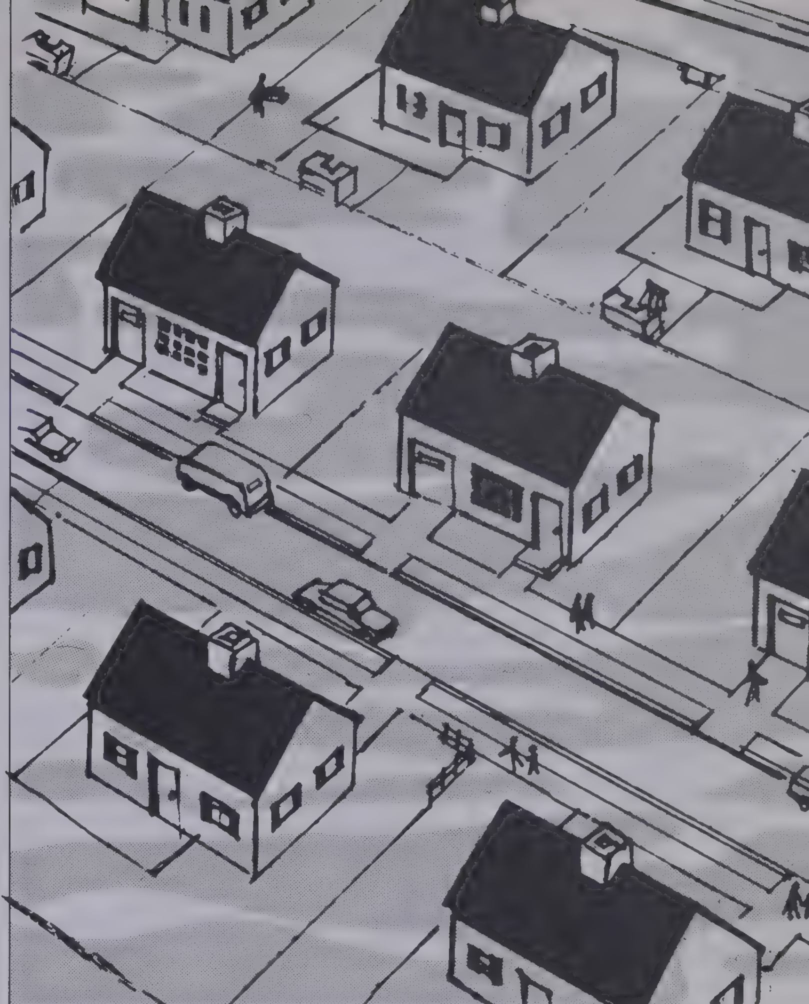


J. Eyerman from Black Star



Elliott Erwitt, Magnum Photos, Inc.

To complicate matters, the number of people in California also goes up every year. In housing developments for them, one-fourth of the land is covered by sidewalks and paved streets.



For every gallon of gasoline burned in an automobile engine, about as much air as is in a twenty-foot-long living room will be used.

20. Could you breathe this air after the car has used it? Explain.

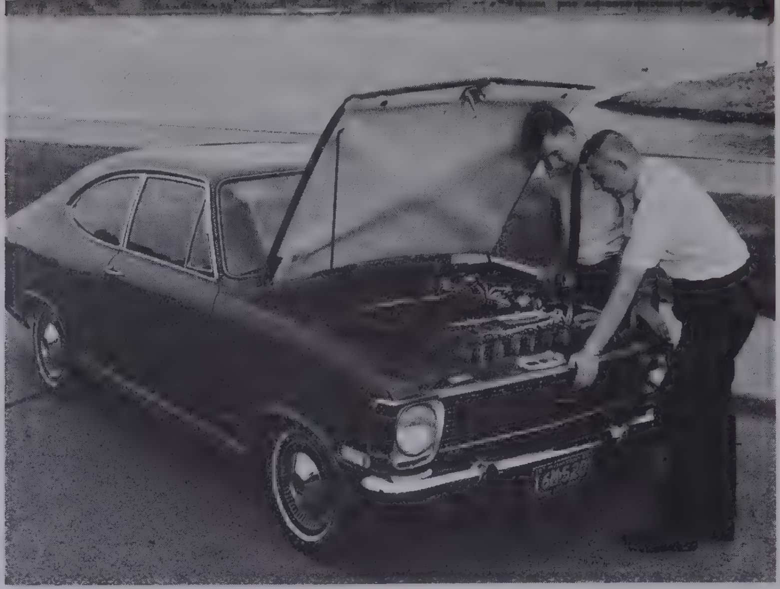
Unwanted substances are thrown off in automobile exhaust fumes. Most dangerous are carbon monoxide and sulfur dioxide. A modern high compression engine also makes chemicals out of the oxygen and nitrogen in the air. All these chemicals combine to cause smog.

Smog makes your eyes water; it burns your nose and throat. It is thought to be responsible for some lung cancer and for a lung disease called *emphysema.* When smog drifts out of the city it causes millions of dollars in damage to food crops.

21. Suggest some remedies for cleaning up the atmosphere.

The National Air Pollution Control Administration

Elliott Erwitt, © 1966 Magnum Photos



General Motors Corp.

The GM Stir-lec I

Now let's look at the other side of the coin. If one of your remedies has to do with limiting the number of cars, there's a problem. One out of every seven jobs in the United States is in some way related to motor vehicles.

22. What would happen to these jobs if we cut down the number of vehicles in operation?

23. What do you expect will provide solutions to the problem of pollution?

E. MEANWHILE, BACK UNDER THE HOOD

24. What moves the piston in a gasoline engine?

25. What moves the rotor blades in a turbine engine?

CONCEPT SUMMARY.

U.S. Air Force Photo

Investigation 6

Stop Fuelin' Around

"Fill 'er up." "Get a 10-pound sack of charcoal." "Pay the gas bill." "A hamburger and a chocolate malt." We hear these words every day. They don't sound alike, but they all have one thing in common: they all concern fuel.

Engines use fuel when they do work. People and animals consume fuel in the form of food. Many materials are used as fuel. Natural gas, gasoline, oil, peat, wood, and coal are some of them. Milk, bananas, and T-bone steaks are others.

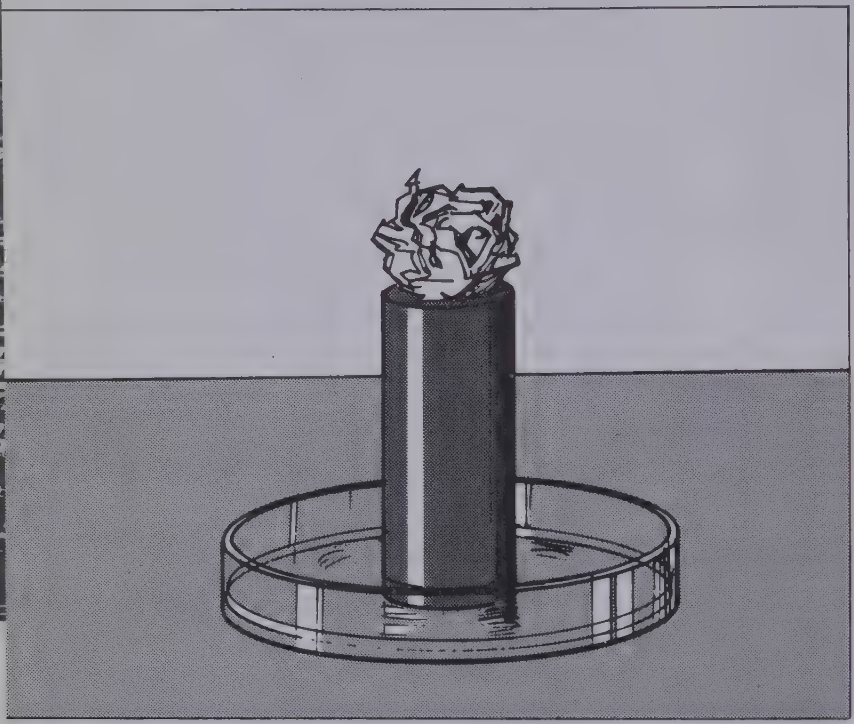
U.S. Forest Service Photo

Humble Oil & Refining Co

Melvin from Monkmeyer

George Porter, National Audubon Society

What happens when fuel is used? How is it changed? Gasoline going into the tank doesn't look like the blue-gray smoke that comes out of the exhaust pipe. But that is all we see. How are fuels changed as they are used?



A. THERE'S BEEN SOME CHANGES MADE

1. Make a prediction about what happens to fuel when it is used to do work.

2. Put 2 ml of alcohol in a dish. Light it. What do you observe?

3. What is left when it has finished burning?

4. List the properties of a piece of paper that can be found by just looking at it and touching it.

Crumple a 3" x 3" piece of thin tissue paper and put it on top of the platform sitting in water in the plastic Petri dish. Light it.

5. What do you observe?

6. Describe the properties of what is left.

7. Is what remains still paper? Explain.

B. FIRE AT SEA

We have watched several things burn. It took a little heat to get them started; then they took off. But we have not really pinned down the question about what is happening. For instance, do fuels burn by themselves?

8. If we didn't *see* anything else when the paper burned, does that mean nothing else was involved? Explain.

Repeat what you did with the crumpled tissue paper. When the paper is burning well, put a clear plastic jar over the platform and paper. Press the jar down into the water.

9. What do you observe?

10. Describe what is left.

11. What do you think was missing this time that had been present before?

12. From the results of questions 10 and 11, what can you say is happening when fuels are doing work?

You have seen fuels doing work. You know that work is force times distance. A gallon of gasoline is not in itself miles and force. Yet, when the gasoline burns, something is released that can apply force and thus do work.

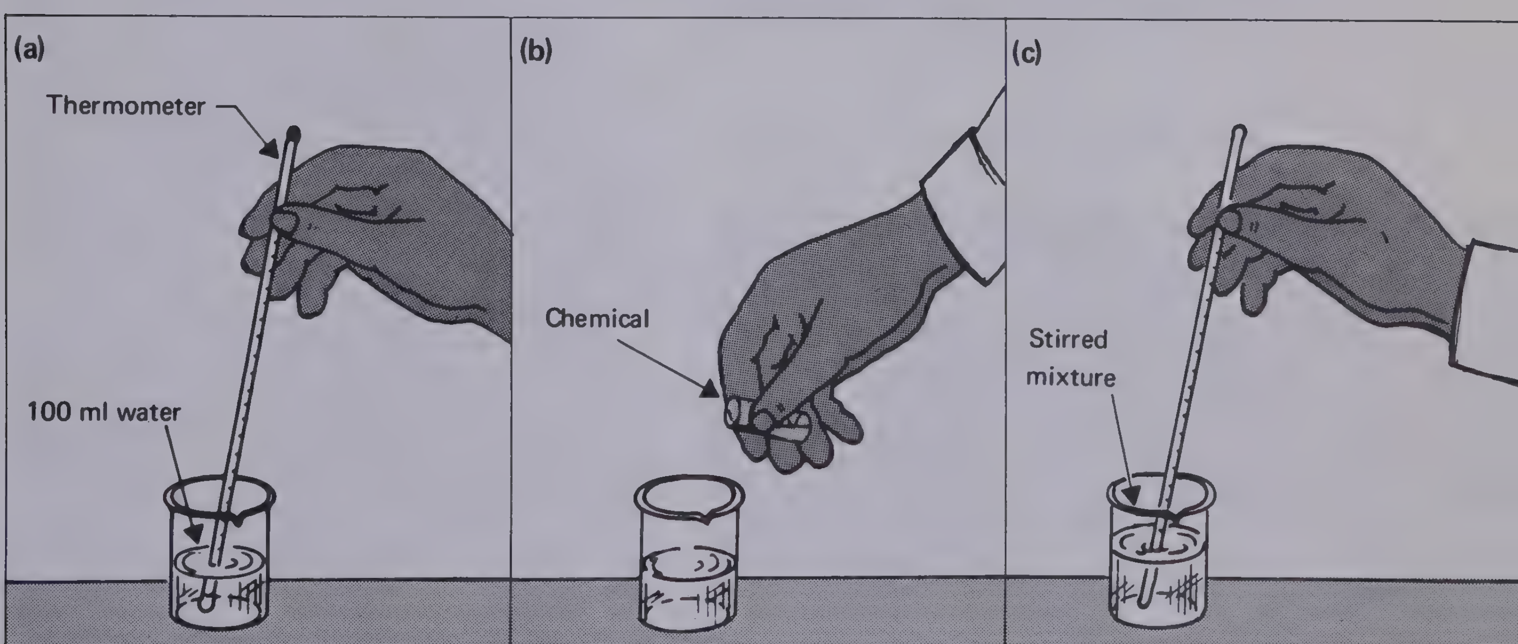
13. What is the word used to describe this ability to do work?

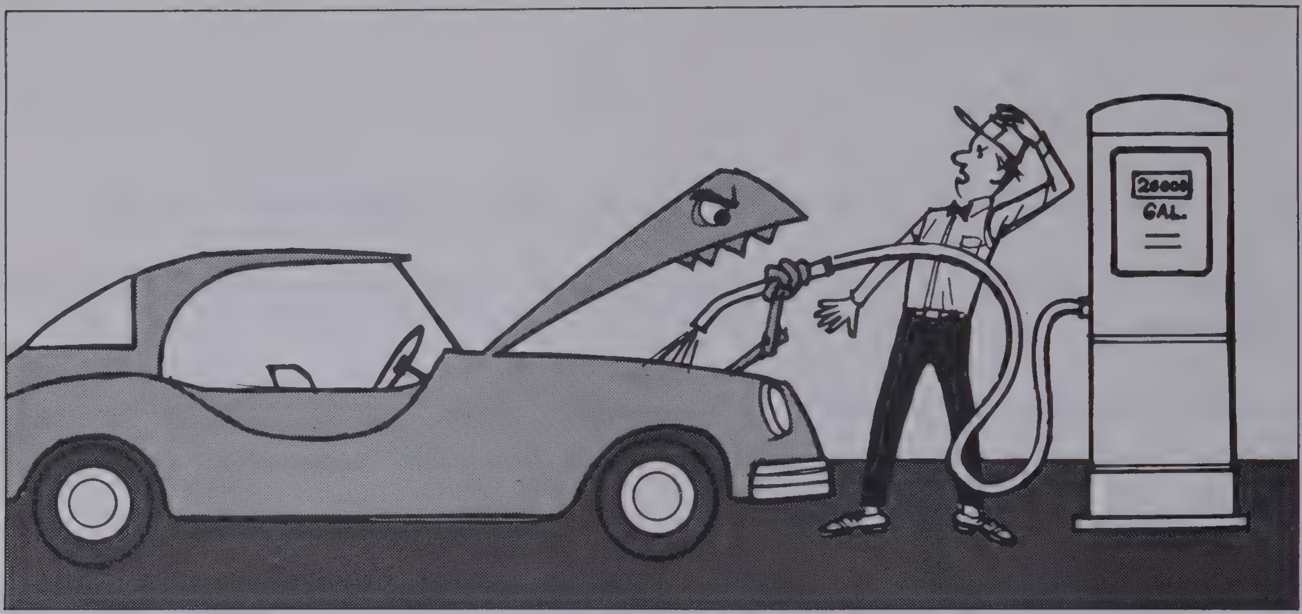
C. IN OR OUT?

Some water has been kept at room temperature. Measure 100 ml of this water into a beaker. Take the temperature of the water and write it in Table No. 1.

Measure 5 ml of Chemical No. 1 into a vial. Pour the contents of the vial into the beaker. Stir it with the thermometer for 1 minute. Take the temperature of the solution. Write the temperature in Table No. 1.

Rinse the beaker and the vial. Dry the vial carefully. Then repeat with as many chemicals as are set out at the front of the room. Write the data in Table No. 1 and complete the table.





14. What happened to the temperature when the chemicals were mixed with the water?

15. What can you say about heat energy in each case?

16. In which of the activities in this investigation was energy produced by a single substance alone?

17. When is energy released from fuel?

18. How is your prediction (question 1) doing?

CONCEPT SUMMARY.

Investigation 7

Go Mad with Power

When a car is pushed down the street, force acts over a distance, and work is done. Work can take many forms. We spent some time learning how simple machines could make work easier. We found that different kinds of matter acting together produce energy. Most of our engines run by burning fuel with air.

Are we really digging deep enough? The energy we have talked about so far comes from chemical reactions. Atoms form new combinations in chemical reactions. But chemical reactions are not enough to account for all the energy that is produced in our universe.

A. A PICTURE OF HEAT?

1. If chemical energy isn't enough, where could the rest come from?

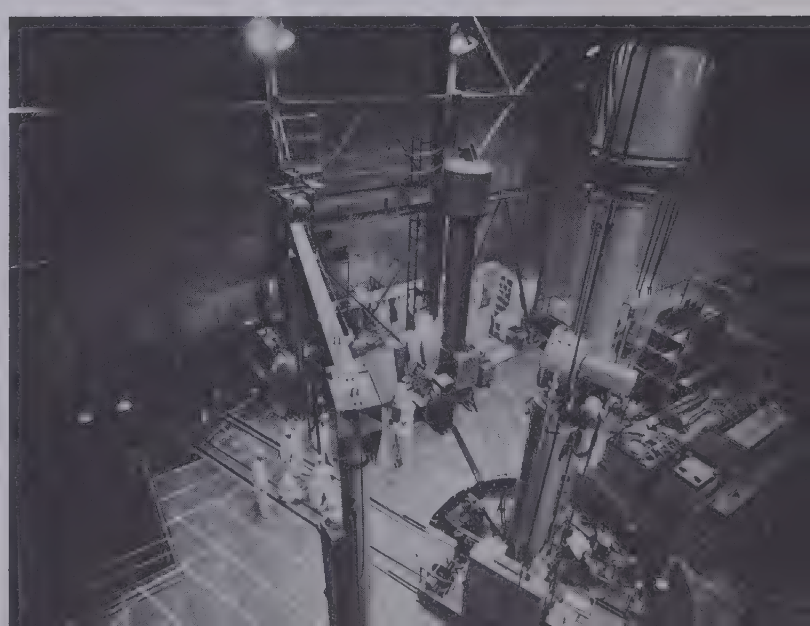
NASA

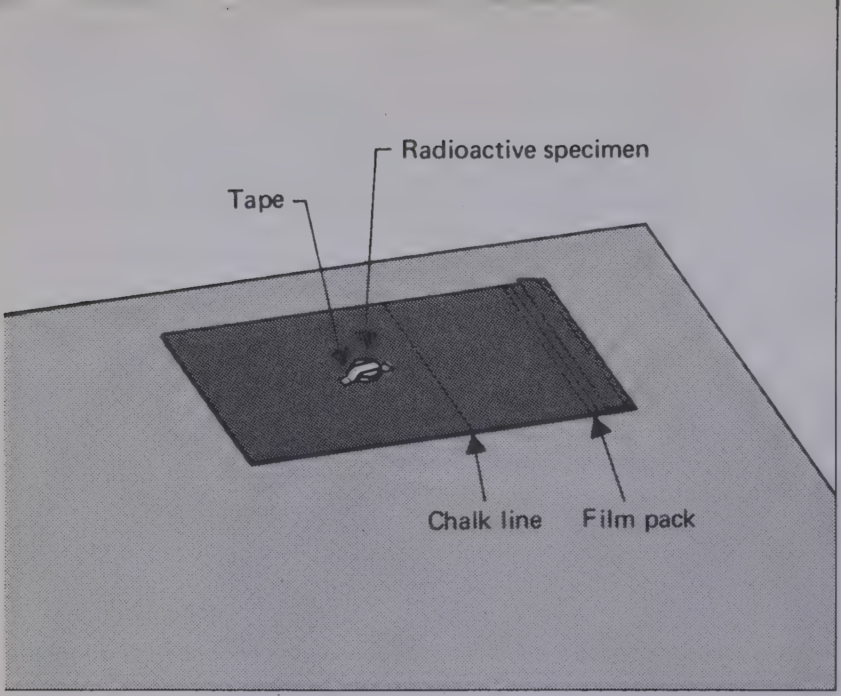
An Apollo blast-off

© Mobil Oil Corp.

Loading fuel elements into the reactor core of an atomic energy plant

General Atomic Division of General Dynamics



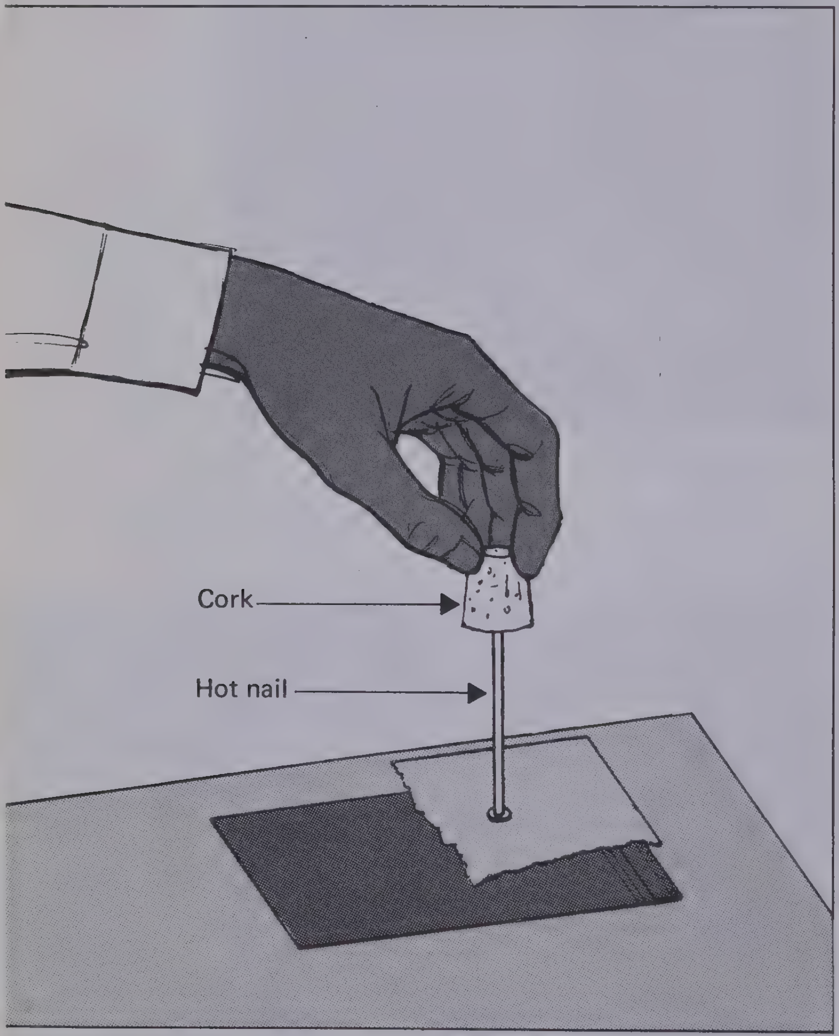


Let's use a piece of equipment most people have seen around a long time: a piece of photographic film.

2. What form of energy is usually used with film?

Let's test to see if the film reacts with other forms of energy. Use a piece of chalk to mark off two areas on the film wrapper. Tape the radioactive specimen to a spot on one side of the chalk line. Leave it there overnight or longer.

When you remove the specimen, use the other part of the film to test with heat. Use a flame to heat the head of a 5-inch spike hot enough to make a brown mark on thin cardboard without making very much smoke. Put a piece of cardboard over the unused half of your film pack. Press the hot spike's head down onto the cardboard, with the film pack underneath. Hold it there about 10-15 seconds, long enough to make a brown mark on the cardboard.



At all times, handle that hot spike with care! It stays hot quite some time.

Now develop your film pack according to the directions given in class.

3. What do you see?

4. How did heat energy affect the film?

5. How did energy from the radioactive specimen affect the film?

B. IT CAME FROM OUTER SPACE

Look deeper into this question of energy sources.

6. Where does most of our energy come from? Clue: It is not from the Earth.

Connect a solar cell to a small electric motor. Point the cell at the sun, and cover and uncover it.

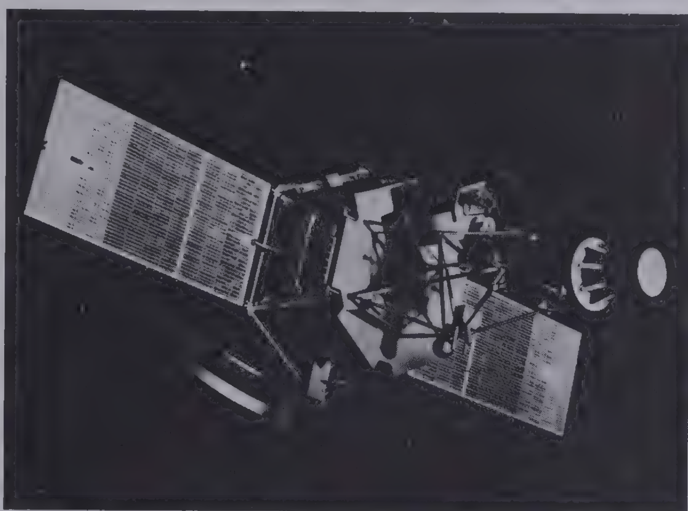
7. What happens?

8. How does this show that some energy comes to the Earth from elsewhere?

9. What are some things that are powered by solar cells?

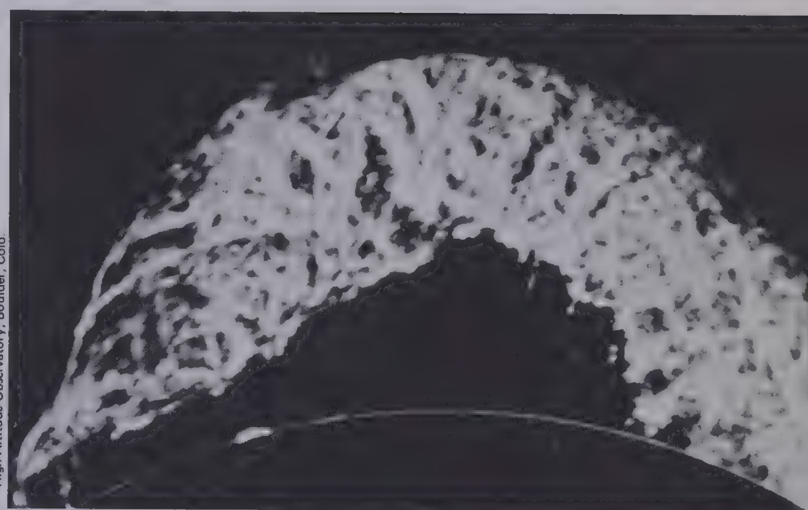
Astronomers tell us that the amount of energy coming from the sun is too great to be from chemical reactions, like burning paper or putting magnesium in acid.

Mariner II spacecraft



NASA

A big solar prominence



High Altitude Observatory, Boulder, Colo.

10. Which of the lab experiments you have done so far in this investigation involved chemical reactions as energy sources?

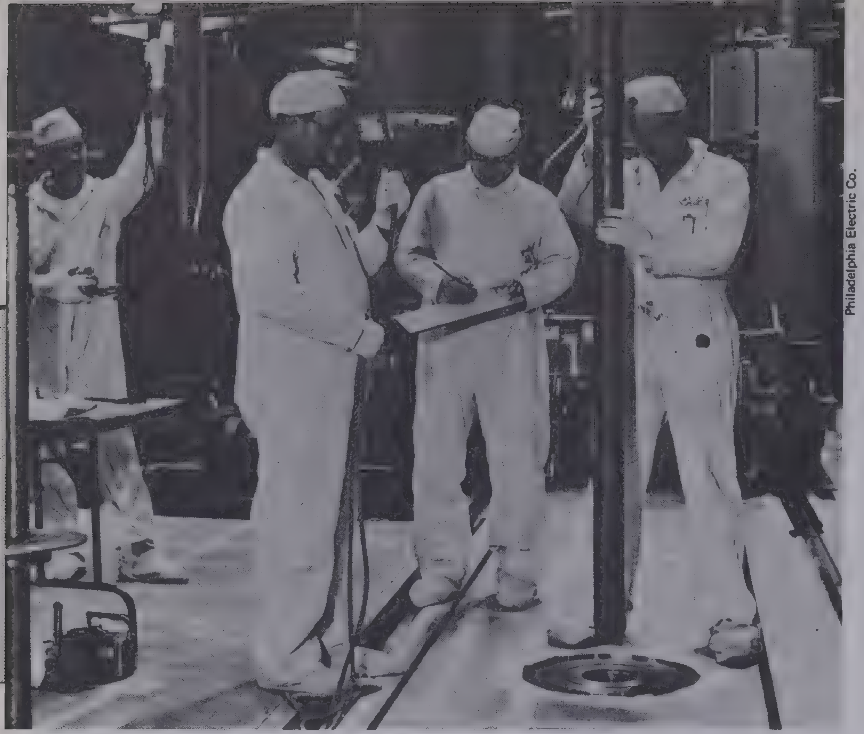
11. So what major energy source is the energy in these experiments like?

C. IT SPREADS LIKE MEASLES

Other than chemical reactions, there are two ways in which atoms produce energy. One way is for several smaller atoms to come together and make one larger atom, giving off a lot of energy in the process. This is called *fusion*. It is the source of the sun's energy.

Almost everyone knows about the other way. One big atom can split into 2 or more smaller atoms, also giving off much energy. This is the way that we get nuclear energy from the atom. Some day our scientists may find a way to create useful fusion energy, just like the sun's.

The machine that makes nuclear energy is called a *reactor*. The reaction by which the energy is released when the atom splits is called *nuclear fission.*



Inspecting a fuel element from an atomic reactor core

In a reactor, when one atom splits, it shoots out two extra neutrons which hit other atoms of the same material. Each of these atoms then shoots out two extra neutrons, which hit still more atoms. These shoot out their extra neutrons, and so on, to keep the process going. As each atom splits, it forms two new atoms of entirely different substances as well as shooting out its two extra neutrons.

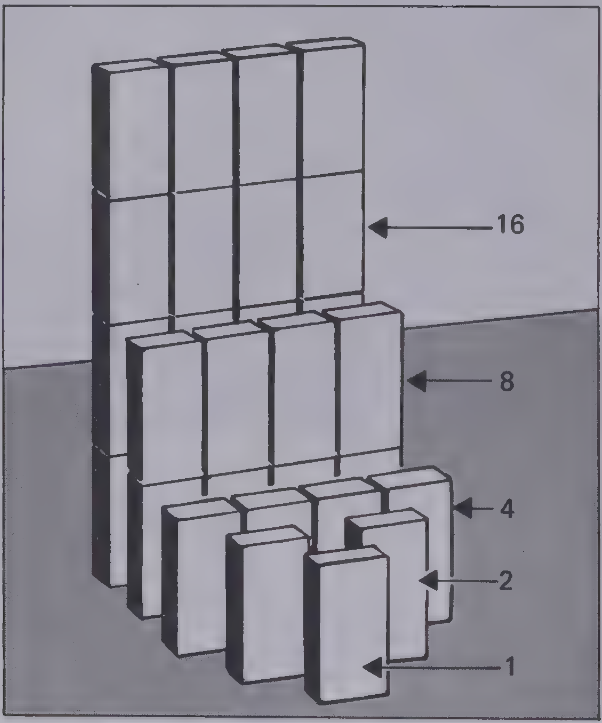
12. What do we call this process?

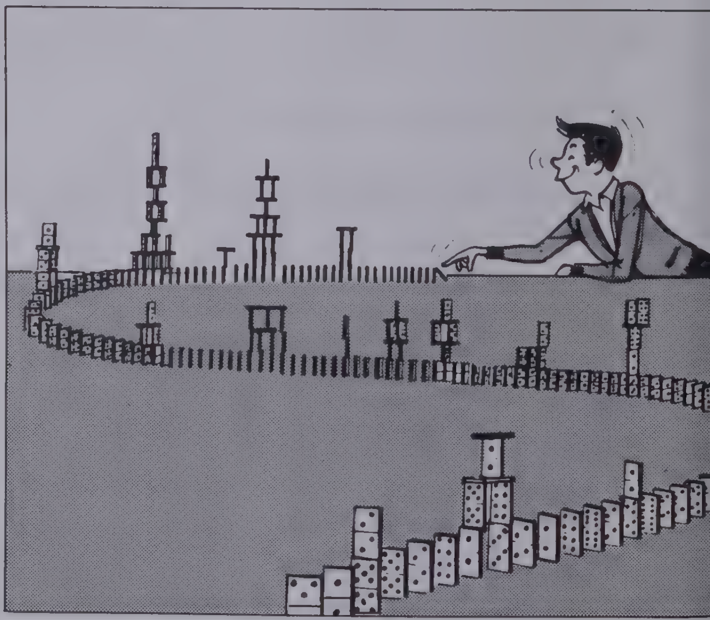
Here is an investigation to illustrate the process. In nuclear fission the number of atoms involved doubles each time. To get the general idea, stand three dominoes on end so that they form a triangle. Have their flat sides parallel to each other. Keep adding rows of dominoes as in the picture, so that the number doubles each time.

When you run out of dominoes, tip the one at the point of the triangle toward the others.

13. What happens?

14. How do your dominoes remind you of the atoms of fissionable material shooting out extra neutrons?





15. Many people are in favor of nuclear power but don't want the power plants near them. Why?

16. Do you agree or disagree with them? Why?

CONCEPT SUMMARY.

Investigation 8

Don't Let It Rub Off on You

There are always problems connected with our use of energy. Too many cars in crowded cities produce traffic jams and smog. Too many engines may some day use up all our natural resources. Without gasoline, our engines will stop.

A. KEEP IT AWAY FROM ME

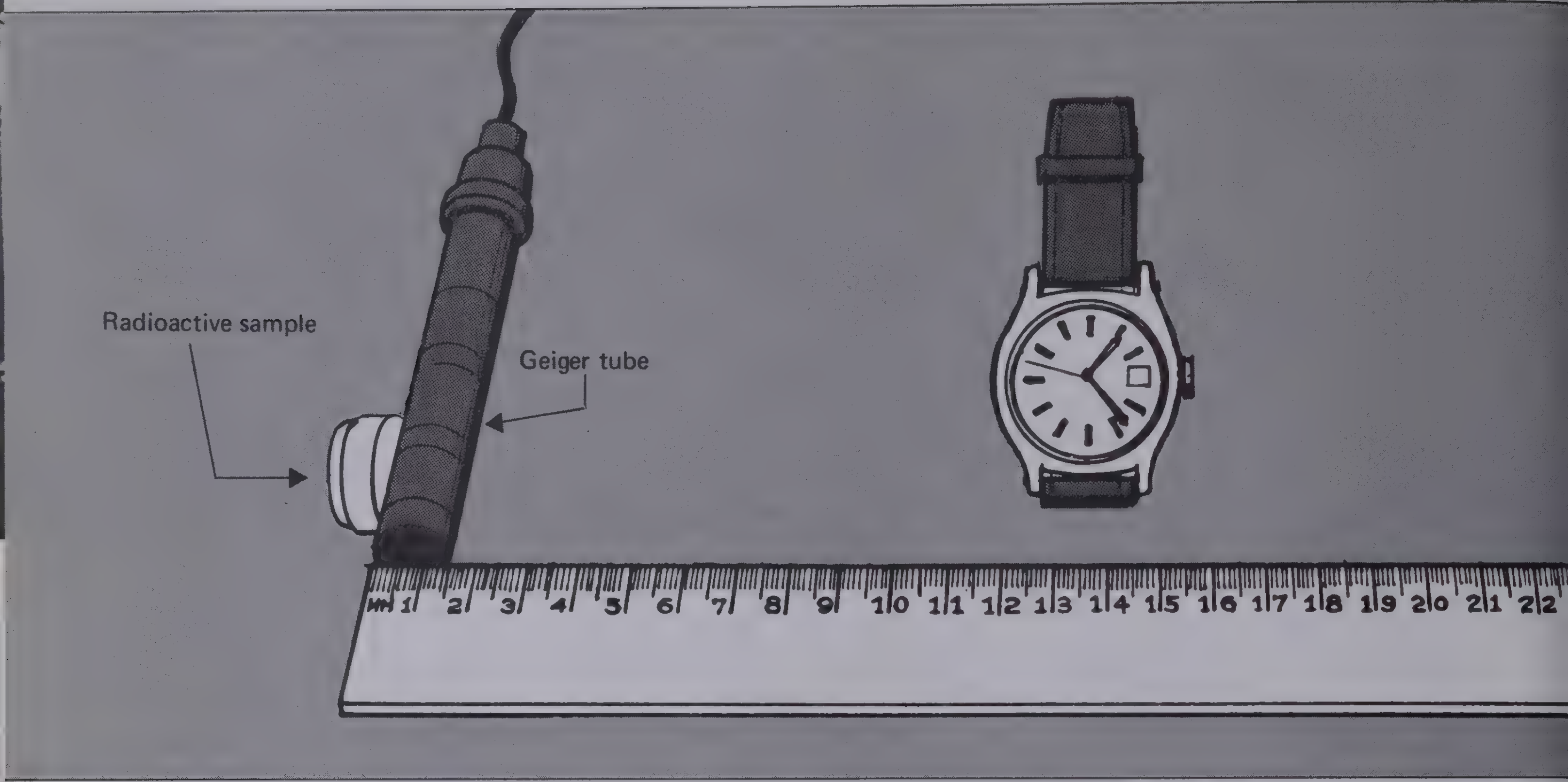
1. Where will our energy come from when all the coal and petroleum are gone?

Nuclear power plants all use large amounts of materials that are radioactive to begin with. But the process of releasing nuclear energy causes even greater amounts of radioactivity. People don't do too well when exposed to radioactivity. What can be done about this?

2. Suggest some possible ways to protect yourself from radiation.

Skin damage caused by radiation

Atomic Energy Commission



Lay the meter stick on the table and put the radioactive sample next to it, at the zero end. Plug the Geiger tube into the nearest high voltage power supply and turn on the power. Put the Geiger tube at right angles to the meter stick, with the hot spot just touching the sample. The point where they touch should be just at the zero mark on the meter stick. Have a watch or a clock with a second hand nearby.

3. Observe what happens. Could you count the pulses per minute? Why not?

Move the tube out to the 64 cm mark and line up the hot spot with the sample. Observe carefully and learn to tell the difference between faint background noises and real pulses. Count the pulses occurring during 1 minute.

4. How many pulses do you count per minute at 64 cm?

5. Do exactly the same thing again. How many pulses per minute this time at 64 cm?

In the same way, count the pulses at 32 cm and at 16 cm. Run at least 2 trials in each case, but do 3 or 4 trials, if you have time. Find the average in each case and record it in Table No. 1.

Move the Geiger tube to the 8 cm mark and observe for a minute without trying to count the pulses.

6. Do you think you could count the pulses accurately at 8 cm? Why?

Even though you may not be able to make an accurate count at 8 cm, you can probably make a fairly good estimate. Learn how to count 4 or 5 pulses that come close together fast. Listen again for a minute at 8 cm and make the best estimate you can. Write it under "Average" for 8 cm.

Things are moving too fast at 4 cm to count, but with high speed equipment scientists have gotten accurate results. Would you guess that the count at 4 cm is 4 times, 5 times, or 6 times the count at 8 cm?

Multiply the count at 8 cm by the number you guessed. Write the result in Table No. 1.

You now have 5 figures for the number of pulses per minute at various distances from the radioactive sample. Plot these 5 figures on Graph No. 1. Connect your 5 points with straight lines. Extend your straight lines as dotted lines past the 2 end points.

7. Between what 2 distances in cm does the graph "turn a corner"?

8. What can you say about the change in the number of pulses per minute as you come in from 60 cm to 20 cm?

9. What can you say about the change as you come in from 10 cm to zero cm?

10. If the radiation from the sample were dangerous to you, as shown by the number of pulses, how far away, at least, would you want to keep the sample from you?

11. What can you say in general about radioactivity and distance?

12. What does this tell you about radiation safety?

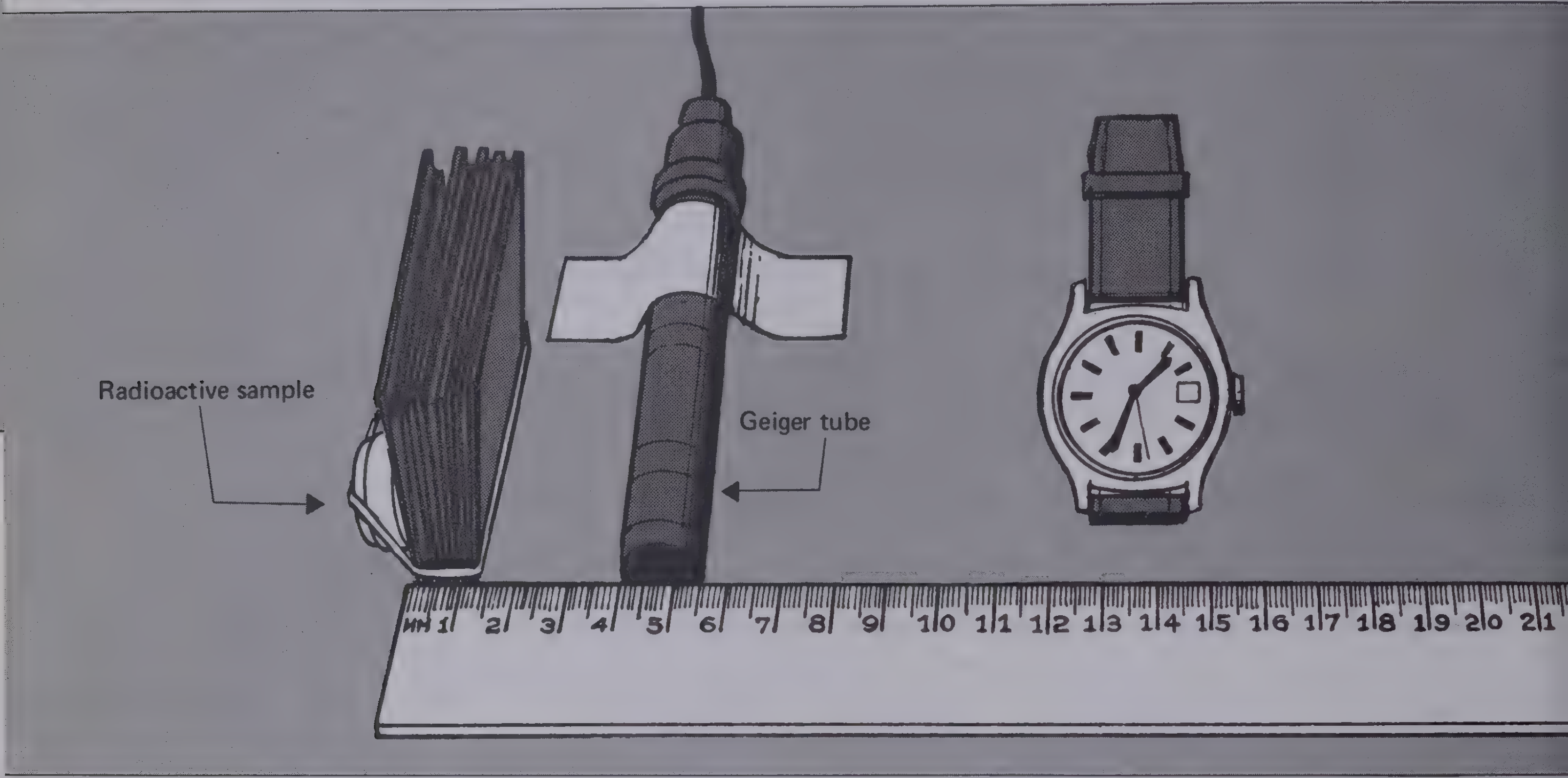
B. STOP THE INVADERS

It's not always possible to keep a long distance away from radiation. Workers in a nuclear plant have to keep a watch on the meters and a hand near the controls. Without protection they would be on the hot spot too long for their own good. How do they get protection?

Take an ordinary 8 1/2" x 11" piece of cardboard, such as is used for backing in pads of scratch paper. Cut it into 16 rectangular pieces of the same size and shape. Stack the pieces neatly like a deck of cards and put a rubber band around them the long way. Slip the radioactive sample inside the rubber band and stand the whole setup on the table at the zero cm mark on your meter stick. Tape the Geiger tube to the table at the 4 cm mark. (Don't put tape over the hot spot.) Plug the tube into the power source.

Turn the shielded sample so that the pieces of cardboard are on the other side of the sample from the hot spot on the Geiger tube. Observe the activity again. Now turn the shielded sample around so that the cardboard is exactly between it and the tube. Keep the sample at the zero mark. Turn the setup around 2 or 3 times between these 2 positions, as you observe. Remember that in both positions the sample and the hot spot on the tube should be exactly 4 cm apart.

13. What do you notice?



Make at least 2 careful counts (3 or 4 if you have time) of the number of pulses per minute with the sample at 4 cm and the 16 pieces of cardboard between it and the hot spot on the tube. Write your results in Table No. 2. Figure the average and record it.

Take 8 sheets of cardboard out of the setup and repeat the counts with the remaining 8 pieces. Run 2 or more trials and record them and the average.

Take out 4 more pieces of cardboard and observe with the remaining 4 pieces as shielding. (Be sure to keep the sample exactly at 4 cm from the hot spot.) Compare the activity with the 4 pieces of shielding to that without.

14. What do you notice? How easily could you make the count with 4 pieces of shielding?

It may be tricky, but you should be able to get counts with the 4 pieces of shielding. Your trials may be a mixture of real counting and educated guessing. Do the best you can to get an average with 4 pieces of shielding. Record it in Table No. 2.

Plot your 3 averages on Graph No. 2.

Use another 16 squares to get results with 32 pieces of cardboard. Record the result in Table No. 2. Also, copy your figure for 4 cm from Table No. 1 into the column for zero pieces of cardboard in Table No. 2. Plot these 2 points on Graph No. 2. Connect all 5 points with straight lines and extend the two outer straight lines as dotted lines to the edge of the graph.

15. At about how many pieces of cardboard does your graph turn the corner?

16. If you had to protect yourself from this radioactive sample, 4 cm away from you, what is the fewest number of pieces of cardboard with which you would begin to feel safe?

17. What do you notice about Graphs Nos. 1 and 2 when you compare them?

18. What can you say in general about radioactivity and shielding?

19. Mention some other substances that you think might shield better, even at very close distances, than cardboard.

20. What do you think each pulse from the Geiger tube stands for?

Think about distance and shielding for a minute. You know that every cubic inch of air around us is full of billions of particles of oxygen and nitrogen and other things. Cardboard also is made up of billions of particles per cubic inch.

Henle from Monkmeyer

C. DECISIONS, DECISIONS

21. You have found that radiation levels are affected by distance. How would you use this fact if you were designing a reactor to be used out in a desert region where land was cheap?

Suppose you don't have unlimited space, and you must use shielding. A concrete block about 4 inches thick, or a sheet of lead about 1/8 inch thick, are about equally good shields. The block costs a few cents. The lead sheet costs several dollars.

22. What would you do if you were building a reactor on the outskirts of a crowded city?

23. Suppose your reactor had to go into a submarine. What would you do?

24. What do you conclude about radiation safety problems?

Wide World Photos

United States atomic submarine "Thomas A. Edison"

CONCEPT SUMMARY.

Investigation 9

But You Can't Get Something for Nothing!

Energy comes from the atom, but this doesn't really finish the story. Just how is the energy released? Where does it come from? Does this change any of our ideas about matter?

The nucleus of the atom is made of two kinds of particles: protons and neutrons. Scientists measured the weights of these particles and the weights of different atoms. Then they began comparing the weights of different atoms with the weights of the particles inside them. They discovered something curious.


Brookhaven Nat'l Laboratory

Nuclear particles colliding in a cloud chamber

A. THERE'S SOMETHING MISSING

The weights of several different atoms and the average weights of their nuclear particles are given in Table No. 1.

TABLE NO. 1

AVERAGE WEIGHT OF NUCLEAR PARTICLES IN SELECTED ATOMS

Name of Atom	Number of Nuclear Particles	Weight of Atom	Average Weight Nuclear Particles
Helium	4	4.0026	1.0006
Carbon	12	12.0000	1.0000
Oxygen	16	15.9949	0.9997
Aluminum	27	26.9815	0.9993
Iron	56	55.9349	0.9988
Krypton	84	83.9115	0.9989
Tin	116	115.9021	0.9991
Iodine	127	126.9044	0.9992
Holmium	165	164.9303	0.9996
Gold	197	196.9666	0.9998
Radium	226	226.0254	1.0001
Uranium	238	238.0508	1.0002

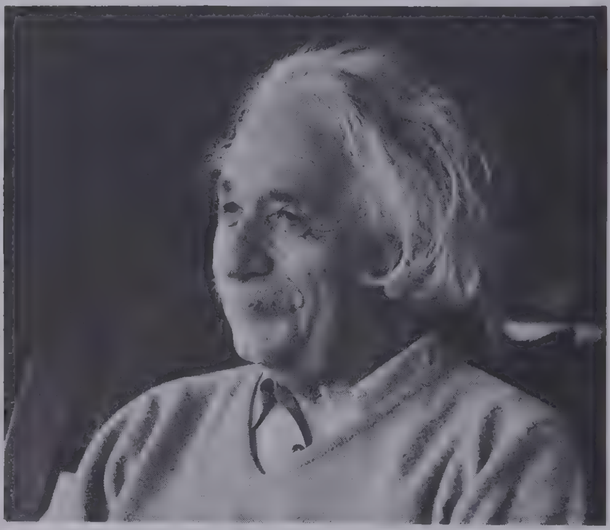
The average weights of the nuclear particles were found by dividing the atomic weight by the number of nuclear particles.

Make Graph No. 1 to get the information in the table in visual form.

1. What seems to happen to the average weight of nuclear particles as atoms get heavier? Be sure to describe what the graph shows you in detail.

Your graph can be used in the study of nuclear energy. When an atom splits, its nucleus takes in a neutron and then blows in half, releasing 2 more neutrons and some energy. Each of these 2 neutrons then proceeds to blow apart another nucleus, releasing 2 more neutrons in each case, and so on. Two atoms of new substances are formed from each split atom.

Let's do a little arithmetic. A neutron weighs 1.0089 units. The uranium^{235} atom that catches it weighs 235.0439 units. In one possible nuclear reaction, the final products of the fission will be two atoms of new substances and two neutrons. One atom will weigh 138.9061 units, and the other will weigh 94.9046 units.



Ernst Haas © 1964 Magnum Photos

Albert Einstein

2. What is the total weight of the particles that came together?

3. What is the total weight of the particles that resulted?

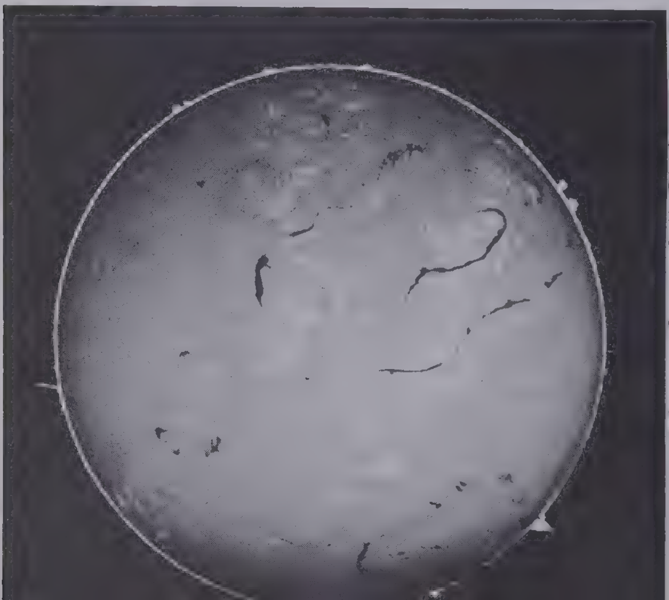
4. What do you find when you compare these two weights?

5. What explanation can you give for this result?

Albert Einstein predicted this result about the time when telephones were first coming into common use.

6. How long ago do you think this was?

The sun seen through a special filter



High Altitude Observatory, Boulder, Colorado

B. NOW PUT IT TOGETHER

The other reaction, the one that is going on all the time in the sun, is *fusion.* This reaction creates enormous energy. In fusion, four hydrogen atoms, each weighing 1.0078 units, combine. They form a helium atom weighing 4.0026 units.

7. What is the combined weight of the four hydrogen atoms?

8. Compare the combined weight of the four hydrogen atoms with the weight of one helium atom, and explain what you find.

So the remains of both fusion and fission reactions have less matter per particle than the original atoms.

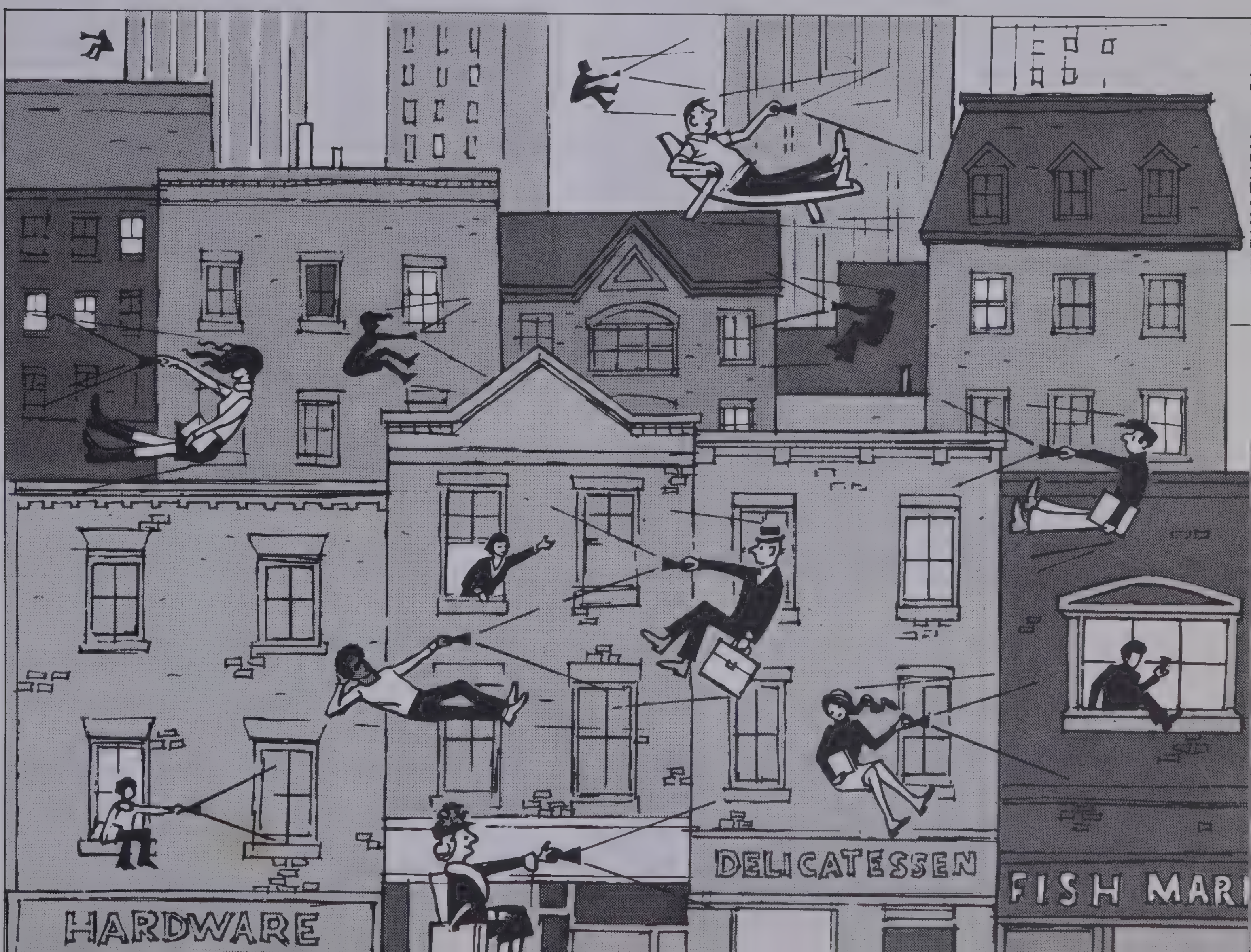
9. Look at Graph No. 1. Where do you find the atoms with the most matter (weight) per particle, at the ends or in the middle of the graph?

10. What are some of the atoms we have mentioned that take part in fission and fusion reactions?

Label the points for the atoms you named in question 10 on your graph.

11. Do these atoms have heavier than average or lighter than average nuclear particles? Explain.

Wouldn't it be nice if there were some simple, do-it-yourself way to get energy from matter? But who knows, maybe someday there will be! Scientists have not yet finished discovering all the ways that nature works.




Richard E. Orville, State University of New York

12. In the case of the fission reaction of uranium, did the uranium atom react all by itself? Explain.

13. In the case of fusion reactions, how many atoms are required?

14. When we looked at chemical energy, was only one substance needed for reactions to occur, or more than one?

15. If matter seems to be lost in fission and fusion reactions, but energy is created, what can you say about matter and energy?

CONCEPT SUMMARY.

Idea 4
Interaction

Investigation 1

Nothing Is Forever

United Press International, Inc.

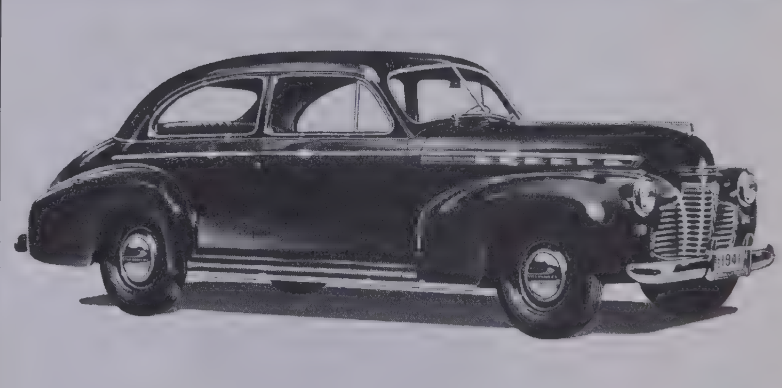
When you come back to a city after a few years, the skyline looks different.

Compare this year's car to the same make a few years back. You will see big changes.

Look at a picture of yourself taken a few years ago. Now look in the mirror. Well?

Man is always at it. He cuts down trees, paves roads, builds houses, then tears it all down to start over again.

Is man the whole story? Or are other kinds of action going on? Let's look at some data.



General Motors–Chevrolet Motor Division

Southern Pacific Co.

Italian Gov't Travel Office

A. THAT'S NOT HOW WE PLANNED IT

Above is a picture of a railroad track in southern California. The builders had not really planned on a submarine train, but...

1. What is your guess about what happened?

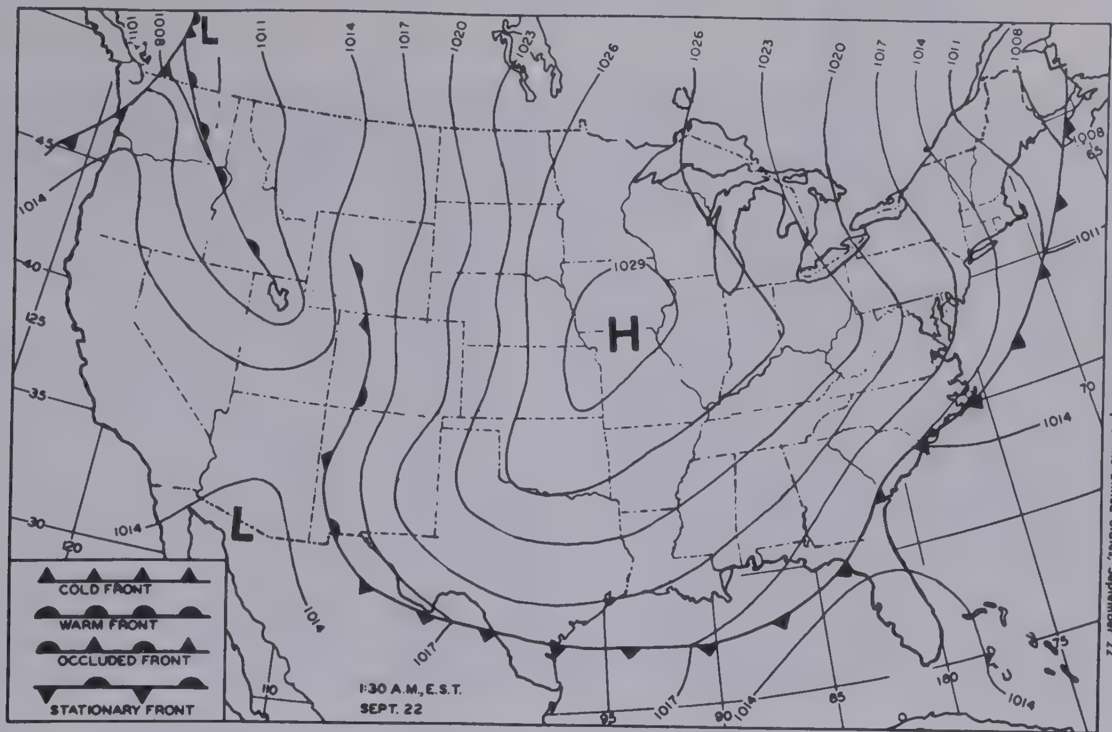
2. What's wrong with the next picture? Why isn't the building level?

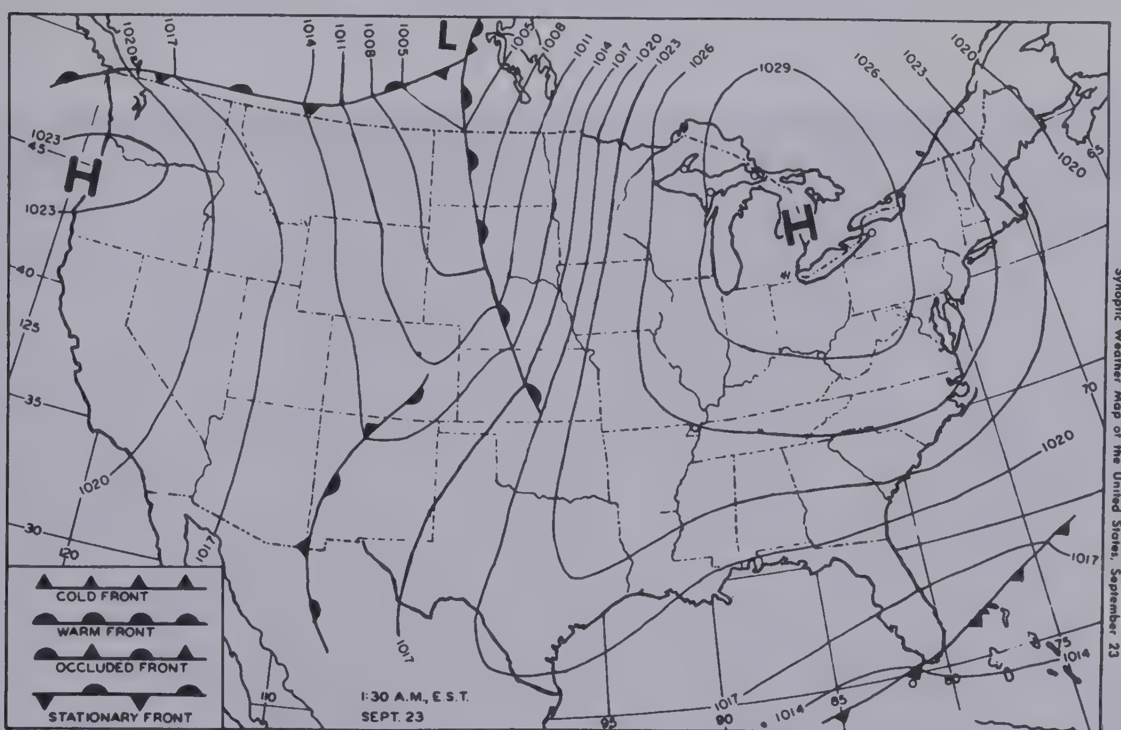
3. What are these pictures saying about the surface of the earth?

B. THE AIR DOES IT

We can't blame men for earthquakes and heavy rains that cause floods. No one yet has moved several miles of rock by himself. If parts of the earth move by themselves, can other things act by themselves, too?

Here are weather maps for two days in a row. Air pressure is the weight of the air over a place. When more air collects in one place the pressure is higher. When there is less air the pressure is lower. The capital letters are the centers of high or low pressure areas.

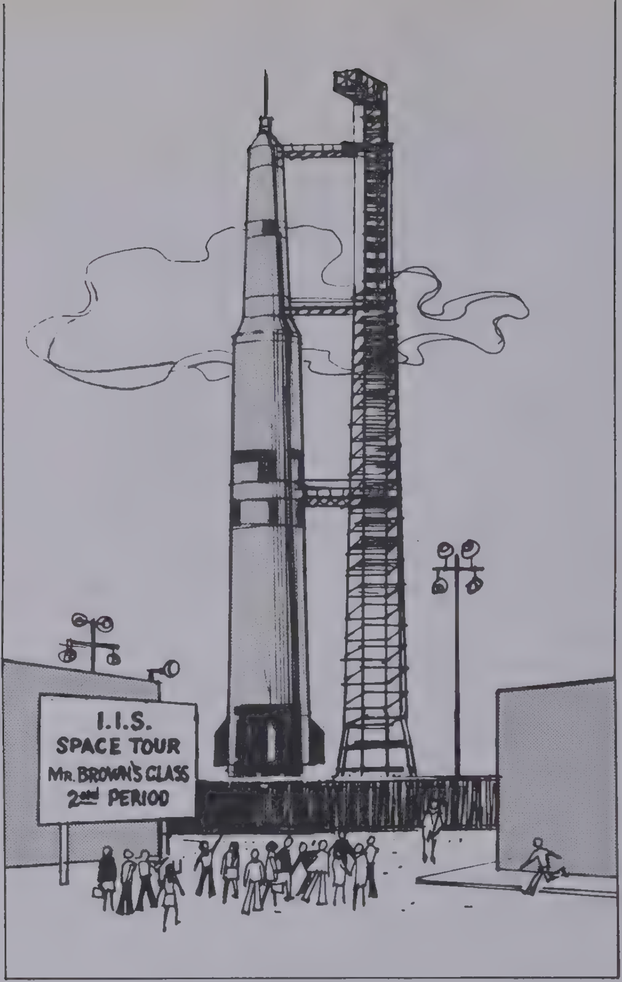




4. On the first map there is a low in western Canada. Where is it the next day?

5. The first map shows a high in the middle of the country. How many states has it crossed in 24 hours?

6. What can you say about the day-by-day condition of the atmosphere?



C. OUT OF THIS WORLD

The earth beneath our feet doesn't remain the same forever and ever. The wind is strong on some days and calm on others. The air we breathe doesn't stay the same from day to day. What else is left? Right: space. We can check the action out there. It doesn't even take a field trip.

7. What time was sunset yesterday?

8. What time, do you think, will sunset take place tonight?

9. What is your prediction about sunset in a week?

10. What shape was the moon the last time you saw it?

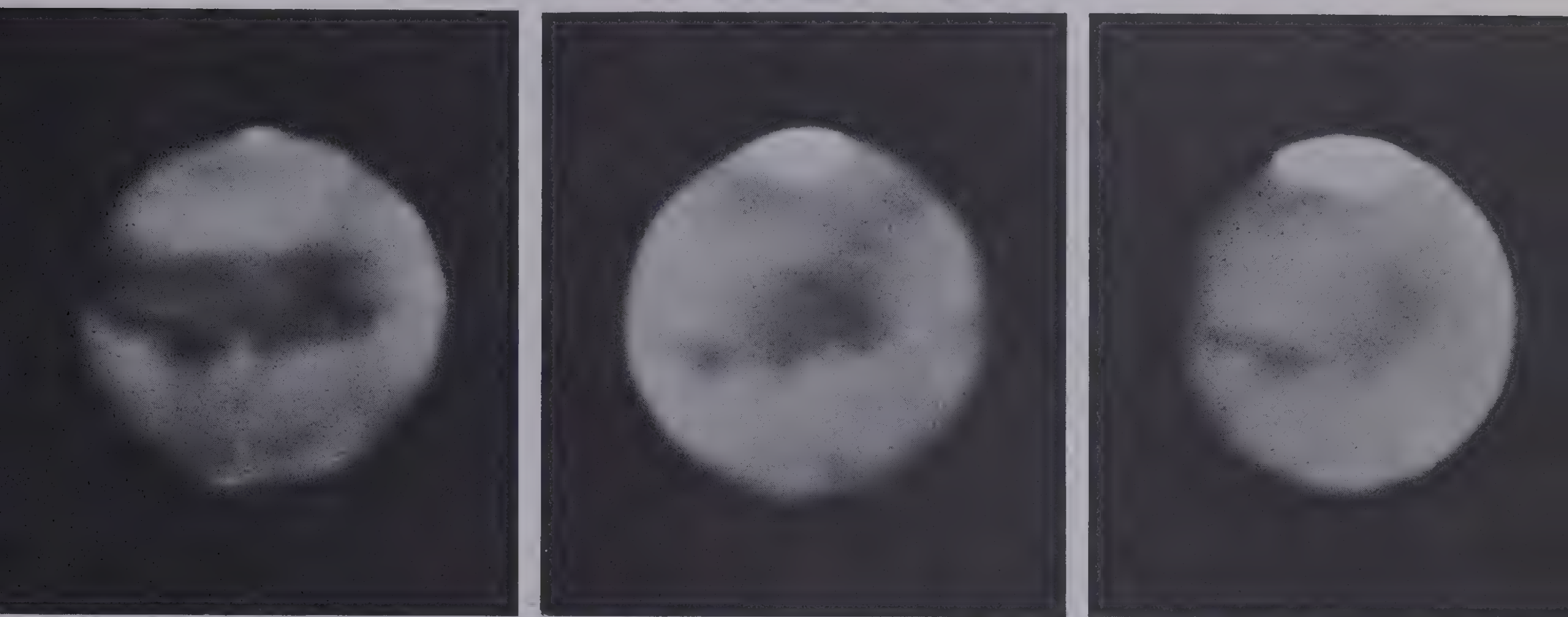
11. Look at the photographs of the moon taken over a period of time. How do they compare?

Moon

Mt. Wilson and Palomar Observatories

12. If the moon seems too close to home for you, we can move out a few million miles. Here are some pictures of Mars. What changes do you observe?

13. What happens to objects out in space as time goes on?



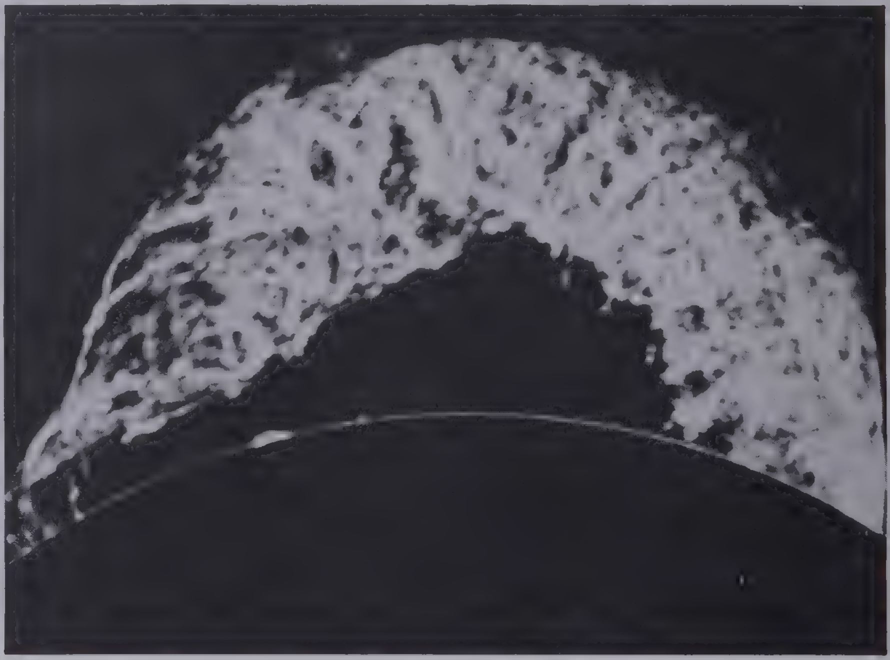
Lowell Observatory Photographs

Mars

D. EVERYTHING IS IN THE ACT

The Earth twitches and wiggles every once in a while. Some nights the moon is full; some nights it is a thin sliver. The moon also complicates matters by being around during the day now and then. The weather can change greatly from one day to the next. There are sunspots some days but not others. Also, bits and pieces keep flying off the sun.

Union Pacific Railroad Photo



High Altitude Observatory, Boulder, Colorado

The earth beneath our feet, the air around us, and the sky overhead are our natural surroundings, our environment.

14. List some of the questions that scientists might ask about the action going on around you.

CONCEPT SUMMARY.

PHYSICAL SCIENCE Idea 4 Interaction

Investigation 2

It's a Breeze

Things keep changing. We can see it in the earth. We see it in space. The sun doesn't rise at the same time each day. The moon also rises and sets at different times; it even seems to change shape. Sometimes it hangs around during the day and gets in the sun's way.

Courtesy of California Palace of the Legion of Honour

Wide World Photos

Then there is the weather. It gets wetter or drier, windier or calmer, hotter or colder. When it gets hot, you may be lucky enough to get down to the beach.

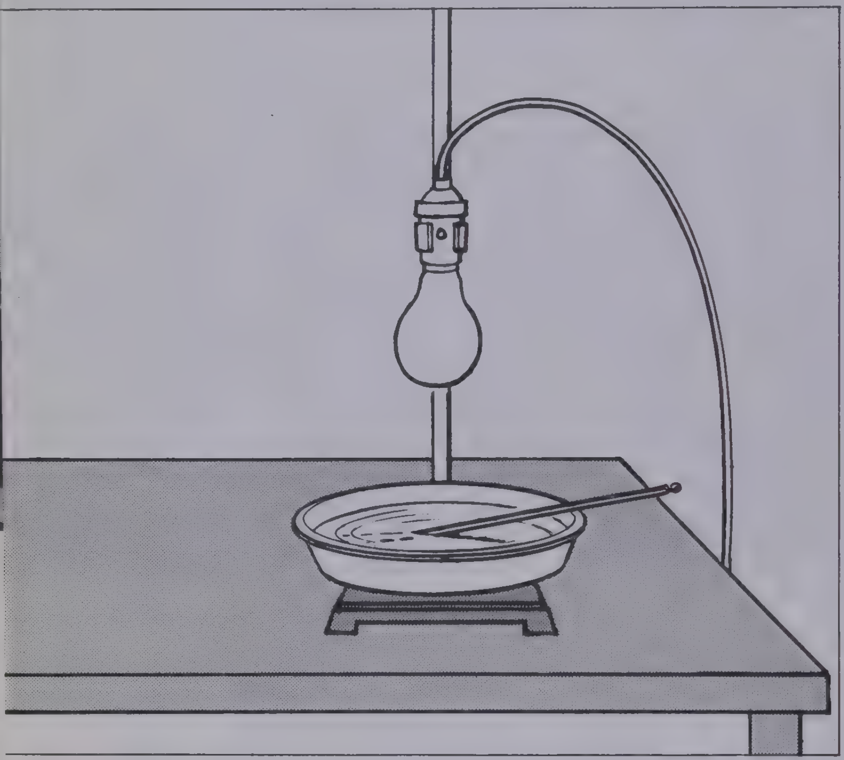
But about that beach: why should one place be cooler than another if they are close together and get the same amount of sunlight?

Sam Falk from Monkmeyer Press Photo Service

A. WET OR DRY?

1. What is your idea? Give your explanation of why it's hot in the city and cool at the beach.

Let's compare the sand and the sea. Half of the groups will use water; the other half will use sand. Each group fills a shallow pan with water or with sand. Make sure the weight of each is equal. In other words, the groups that use sand should make sure that their sand is as heavy as the water that the other groups use.



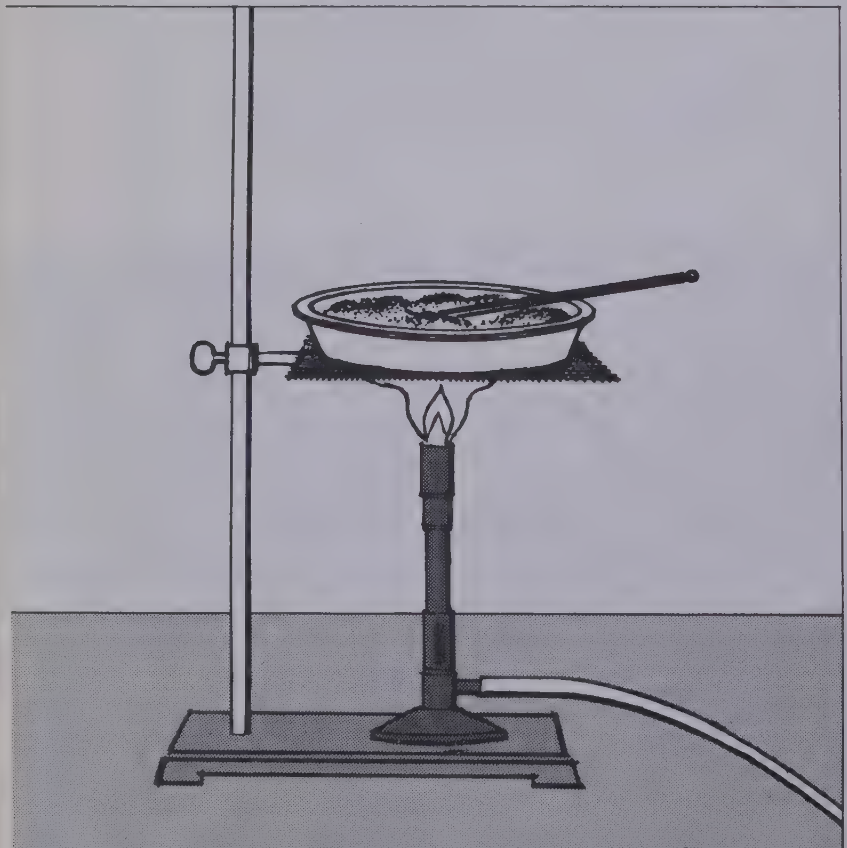
Place the bulb end of a thermometer in the pan. Set a lamp 5 inches above the pan.

Read the temperature of the thermometer and record it in Table No. 1. Turn on the lamp. Read the temperature every 5 minutes for 20 minutes. Write the class data on the board and in Table No. 1.

2. As time passed, what happened to the temperature of both the sand and the water?

3. How did sand temperatures compare with water temperatures?

4. Where will air be warmed more, over sand or over water?



The other half of the story should also be investigated: how fast do sand and water cool off?

Use a burner to warm the sand or water to 40°C. With sand, be sure it warmed evenly all the way through. Remove the burner. Put the thermometer in the pan and read it every 5 minutes for 20 minutes. Write the class data on the board and in Table No. 2.

5. How did the sand temperatures compare with the water temperatures?

6. Where would air be warmer at night, over land or water?

7. Where would you expect the biggest temperature change, on an island or in the middle of a desert?

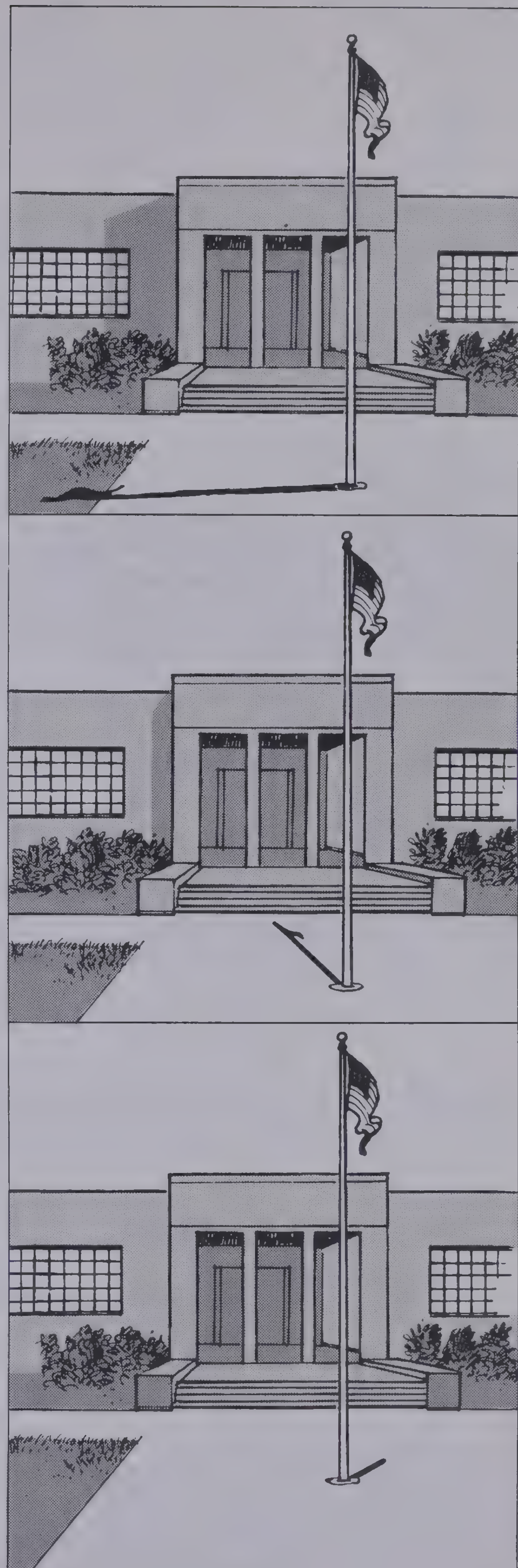
San Francisco, California, is surrounded by water on three sides. Omaha, Nebraska, is surrounded by about a thousand miles of land on all sides. In January, San Francisco temperatures go down to 40°F. Omaha temperatures go down to 10°F.

8. Where would you need the thickest walls and the biggest fuel supply?

In June the highest temperature in San Francisco is about 60°F. In Omaha the temperature often goes over 80°F.

9. In which city would you use an air conditioner more?

10. If you want constant temperatures, where should you live: inland or near the sea?



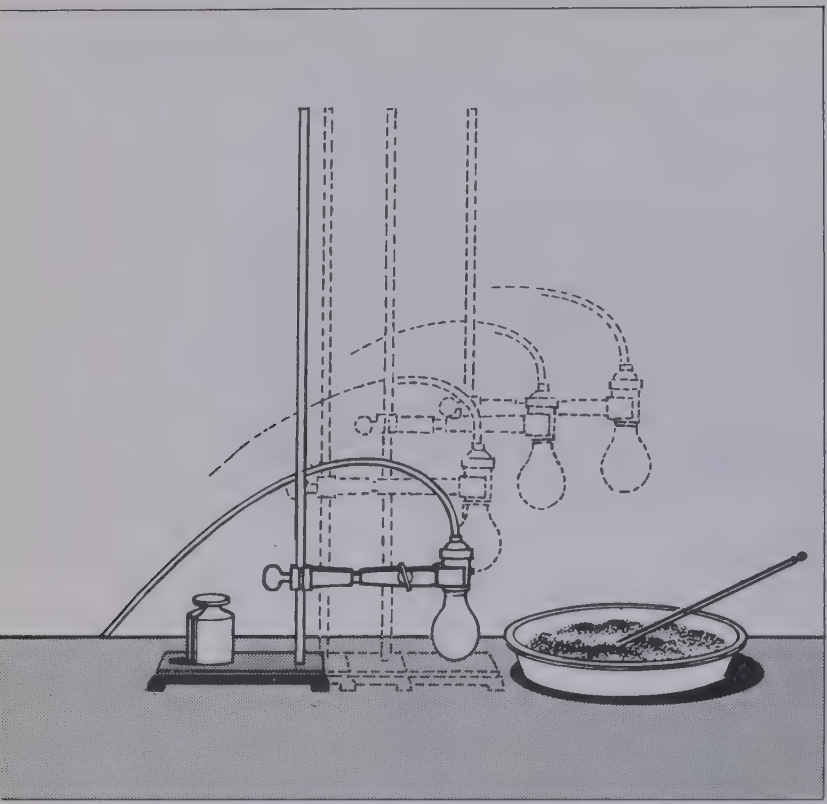
B. HIGH OR LOW?

What else affects the temperature? Why is it hotter in summer and colder in winter? Why is it hotter at noon than early in the morning?

We know one thing that changes—the sun. As the sun moves across the sky it begins very low on the horizon, then rises to almost directly overhead, then gets very low again. As it does this, something keeps changing about the way in which the sun's rays strike an unmoving object.

11. What is it that changes? Hint: think of the shadow of a flagpole at 7 A.M., then 10 A.M., then 1 P.M.

We can test the effect of the moving sun with the same equipment we used before.



You will use the pie pan of sand, the lamp, and the thermometer. Different teams will shine light on the sand at different angles. Some teams will shine from the side, some at an angle of 30° with the surface of the sand, others at 60°, and still others from directly overhead. Your teacher will tell you which direction your team should use.

Let's begin. Set your light at the angle your team is using. Put it 2 feet from the sand. Leave the lamp on for 5 minutes.

At the end of this time record in Table 3 the temperature of the sand. Also record in the table the temperature of the sand of the other teams.

12. How does the angle at which the light strikes the surface affect the temperature?

13. What does this data suggest about heat received from the sun at the North Pole (sun low on the horizon) and heat received at the Equator (sun high overhead)?

C. FULL OF HOT AIR

The data show that air is heated to different temperatures in different places.

14. What does a mass of air do when it becomes warmer than the air around it?

Let's find out. Put a balloon over the end of a flameproof test tube. Heat the test tube over a burner.

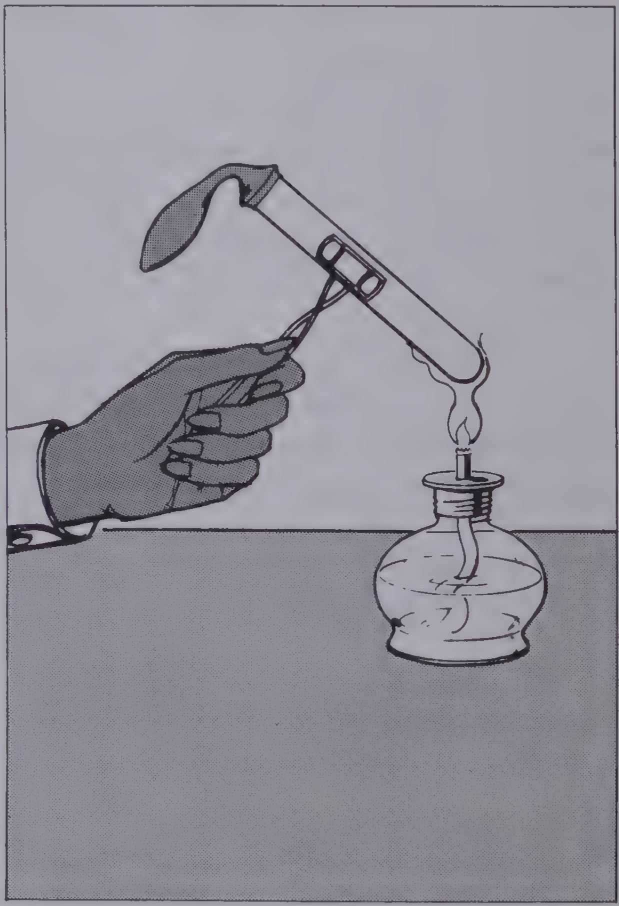
15. What happens to the balloon?

16. Let the test tube cool. What happens?

17. When you can touch it, set the test tube in ice water. What happens?

18. What does air do as it becomes hotter?

19. What does air do as it becomes colder?



20. Summer temperatures in the southwestern deserts go up to 120°F. What do you think happens to the air pressure in your tires after being in that heat awhile?

D. HEAVY OR LIGHT?

So we know what hot air does. Now what does cool air do?

Place a small container of lukewarm water near the edge of the table. Drop in a piece of Dry Ice about the size of a grape.

WARNING: DON'T HANDLE DRY ICE WITH YOUR BARE HANDS!

21. What happens?

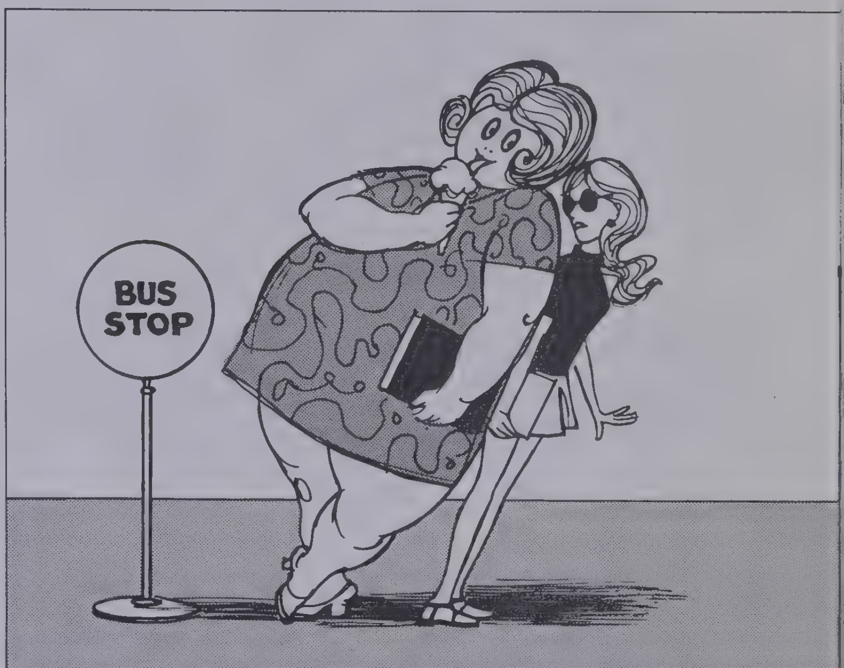
22. Does cold air seem to be lighter or heavier than warm air?

23. What usually happens when something heavy leans on something light?

24. Which way would you expect the wind to blow at the beach on a hot day?

In places where there are mild winters with occasional killing frosts, orange trees are planted on the sides of hills, but not at the bottom.

25. Why are the hillsides safer for the oranges?



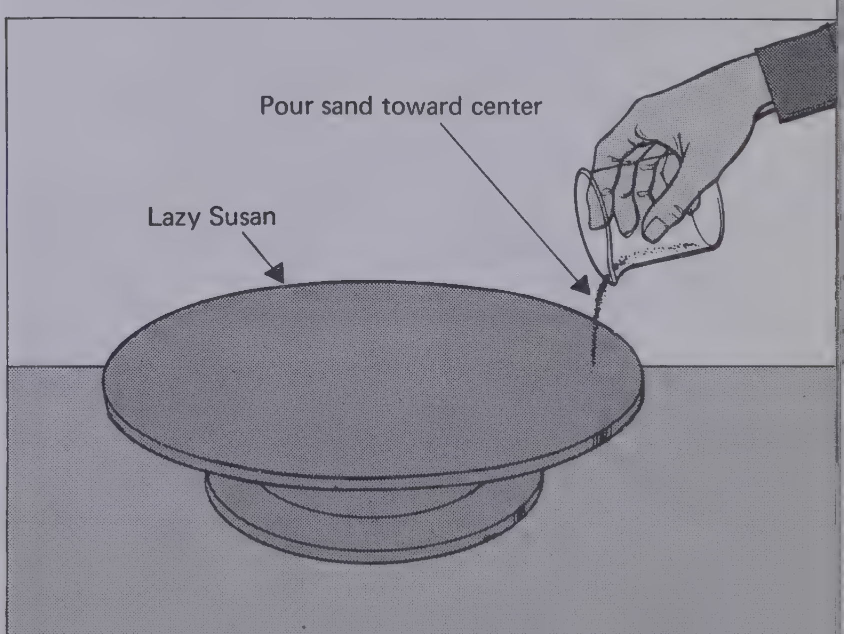
E. YOU CAN'T GO STRAIGHT ON A SPHERE

From the data about cold heavy air and warm light air, it would seem that most winds should blow north to south in the U.S. They don't. Everyone knows the North Pole is covered with ice and it's hot at the Equator. But the winds don't seem to cooperate.

26. If they don't blow directly north to south, in what direction would you guess that regular winds do blow?

We have one clue: the Earth is rotating on its axis. Let's see how this affects the direction things move in.

Put out the round disk. Take a small container of dry sand. Pour it in a straight line from the edge to the center of the disk.



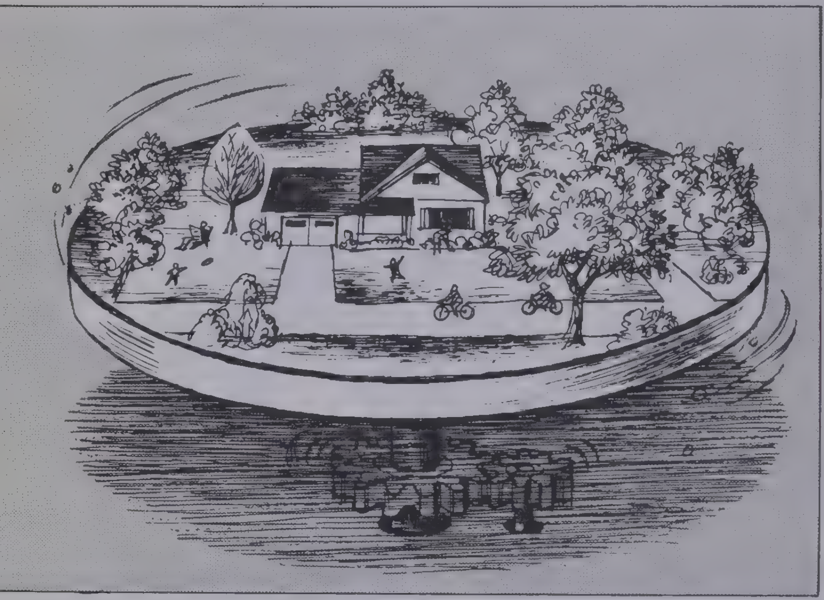
27. What shape does the sand take on the disk?

Start the disk turning clockwise. Pour the sand just the way you did before.

28. What shape does it take on the disk now?

Keep the disk turning. This time pour the sand in a straight line from the center to the edge.

29. What shape does it take now?



30. Suppose you lived on a rotating table. Would a hand up in the sky, pouring sand, seem to move in a straight line? How would it seem to move?

31. If the Earth didn't rotate, what direction might the winds blow?

You have discovered the *Coriolis Force*. It is named for the French engineer who first found it. This force affects the winds. It affects ocean currents. It decides many other things.

The Topeka Capital-Journal

32. If your home is in Kansas City, your life may be suddenly influenced by the Coriolis Force. How?

We have heated air and cooled it. We have moved it about. We have put a little twist to it.

33. What does the sun do to air?

34. What does it take to make anything move?

35. Someone once called the atmosphere a giant engine run by the sun. What do you think?

CONCEPT SUMMARY.

Investigation 3

It's Not the Heat; It's the Humidity

The scene is always changing. The earth changes. The weather changes. Changes occur within a single day. Change never stops.

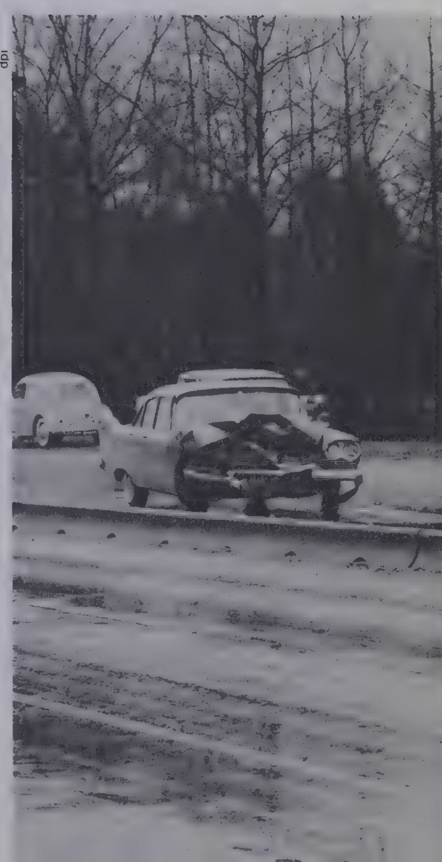
Rapho-Guillumette Pictures

Rapho-Guillumette Pictures

We are finding out why things change. Air and heat energy interact. Heavy cold air can roll under warm light air and push it along. Water heats more slowly than land, so we are sure to find different temperatures in different places. There is always wind somewhere.

There is more to weather than wind. For instance, there is rain. The first part of a rainstorm usually causes the most traffic accidents. A film of oil forms on the road and takes some time to wash off. It also takes time for poor drivers to come off the road. But what about the water itself? Where does rain come from and what decides when it comes down?

United Press International, Inc.



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Canadian Consulate General–NFB

A. CLEAN HANDS FOR SCIENCE

We know there is water in the air; every rainstorm tells us that. We have some ideas about how it gets there. The hint comes from every clothesline. The clothes do get dry. Maybe drying can tell us something about water entering the air.

Make your hands equally wet. They should not be dripping. Keep your left hand still at your side. Swing your right arm around in a circle. Keep it up for at least thirty seconds.

1. Now look at your two hands. Which is drier?

2. Which hand is colder?

There are more ways of getting rid of water than by just waving it away. Add about 20 ml of water to a flameproof dish or beaker. Place it over a burner and heat it.

3. After a short time, what has happened to the water?

B. WET WIND, DRY WIND

When we waved wet hands around, the water went into the air. When we heated water, it went into the air. How can we get some of this water back?

Take a shiny metal cup. Fill it half full of water. Add pieces of ice until it is almost full. Now keep looking at the outside surface of the cup.

4. What happens after a while?

A car is sometimes wet early in the morning even though it didn't rain.

5. What do you think happened to the car's temperature during the night?

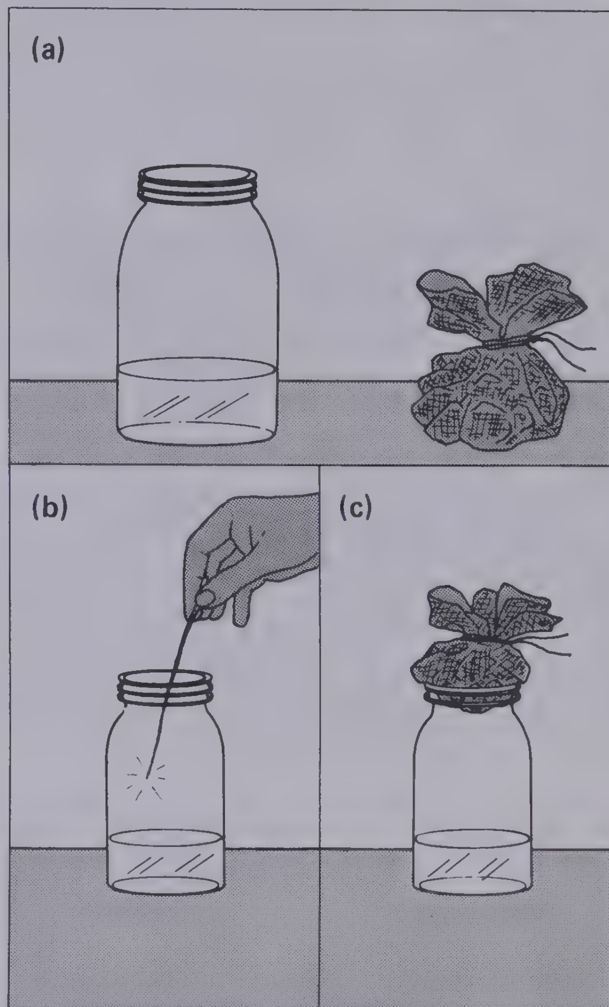
So drops of water form on cold surfaces. It happens on cars and cold cans from the refrigerator. It even happens on eyeglass lenses. But what happens when it rains? There are no cold metal cups up in the air. We see clouds and know they bring rain, snow, and hail. Clouds form in air. Air may be warm or cold. Let's cool some air and see what happens.

Laurence Fink

Fill a jar about one-quarter full of warm water. Tie some pieces of ice in a piece of cheesecloth. Make the bundle larger than the mouth of the jar. Place the bundle of ice on the mouth of the jar and observe the jar for a few minutes.

6. What is happening inside?

7. What is floating around in the air that might be missing in the jar?



Light a splint and let it burn for a moment. Blow out the flame so the splint glows. Lower the glowing splint into the jar for 1 or 2 seconds, then remove it. Place the bundle of ice on the mouth of the jar.

8. Observe the jar for a few minutes. What is happening inside?

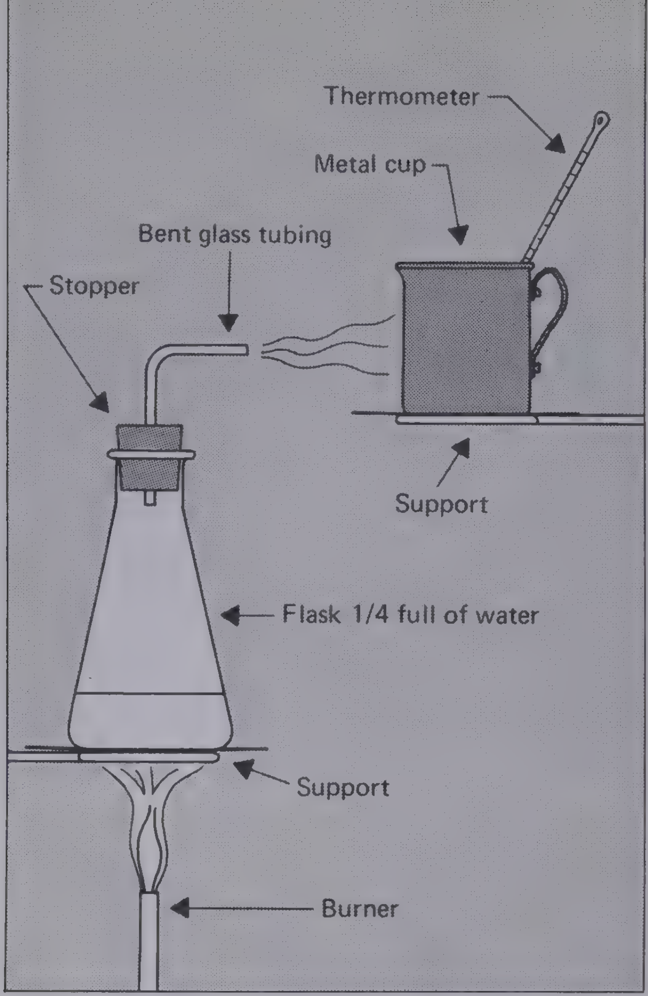
9. What did we do to the air in the jar to get this result?

10. What did the glowing splint add for the fog to form around?

C. HOT OR COLD

Gaining heat has one effect on water; losing heat has another. Let's put them both together.

Fill a flameproof flask about ¼ full. Add some boiling chips. Put in a stopper very tightly with a piece of bent glass tubing through it. Fill the metal cup with cold water and put in a thermometer.



11. Record the temperature.

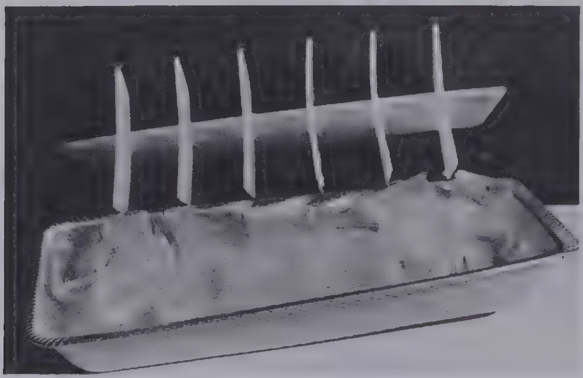
Place the flask over a burner. Put the metal cup on a support. Keep the glass tube pointed at the metal cup. Let the water in the flask begin to boil.

12. What happens on the side of the metal cup?

13. Allow the water to boil for 5 minutes. Write in your data sheet the temperature of the water in the cup.

14. Which way did heat go between the cup and the steam?

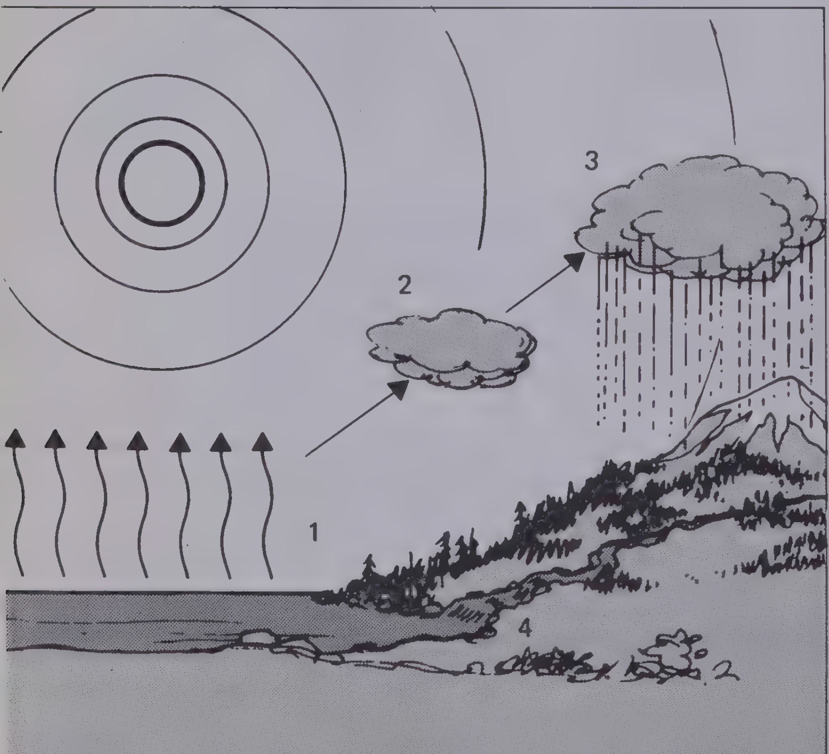
15. What happened to the steam when it hit the side of the cup?



All through this investigation water has been gaining or losing heat. It has also been changing its form. Sometimes it is a liquid and sometimes a gas. How are the heat in the water and the form the water takes connected? Let's examine our data.

16. When water was placed over a burner, heat was added. What form did the water take?

17. When the cold, metal cup took heat from the air, what form did the water in the air take?



Water actions form a pattern. A heat change causes water to form a gas. Another heat change causes water in the form of a gas to become a liquid. The refrigerator takes heat from water to make ice cubes. Changes like these also take place in our atmosphere. There are always some of the three forms of water around somewhere.

Trace the interactions of water and energy in the chart.

18. What is the sun's energy doing to water at Position 1?

19. Why did the cloud at Position 2 move from the sea toward the land?

20. What is the cloud at Position 3 doing, and why do you think this happened?

21. What acted on the rainwater to bring it back to Position 4?

D. WATER AND YOU

Water moves from place to place. Some moves absorb heat. Some moves release heat. By doing all this, water works for us. Your wet hand in part A showed how.

22. How do you feel when you are wet from swimming or a shower, and wind blows on you?

23. On a hot day, you perspire a lot more than on a cold day. How is perspiring useful to you?

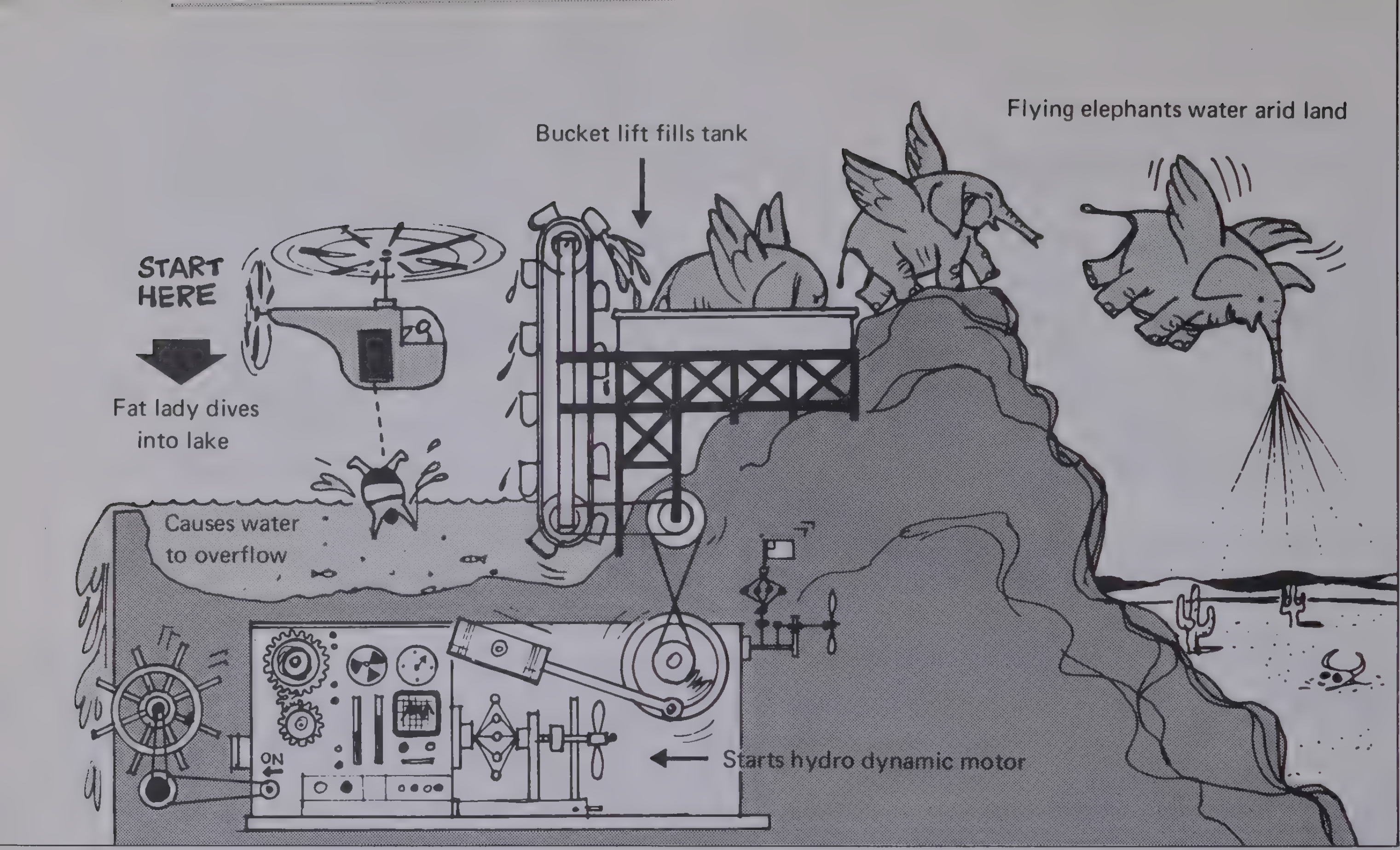
24. Some deodorants can stop you from perspiring. How might this be harmful?

We can't get along without water. We drink it, wash in it, use it in industry, swim in it, and irrigate crops with it.

In many parts of the world the water supply is too small. There isn't enough clean water to do all of the jobs. This is true in many parts of the U.S.A. There are plans to do something about it. One is to pump water from Canada to Mexico. Another would have ships bring icebergs down from the Arctic.

Bob S. Smith from Rapho-Guillumette

Official U.S. Navy Photograph



You have heard of plans to make rain. Sometimes, even when the energy is right, it doesn't rain. Scientists scatter special particles in the air to start things going. It's called seeding. You used something like this system when you made fog in a jar.

25. What was the function of the glowing splint?

26. What are some reasons why a government might want to control rainmaking?

27. Whenever water changes its form, what has interacted with it?

CONCEPT SUMMARY.

Investigation 4

We Walk On It Daily

Some students go to the beach and have barbecues in the sand. Others use clay to model pots, jars, and statues. A few grow miniature plants in pots of earth. Your kid brother may get his kicks walking barefoot in mud puddles.

Walt Sanders from Black Star

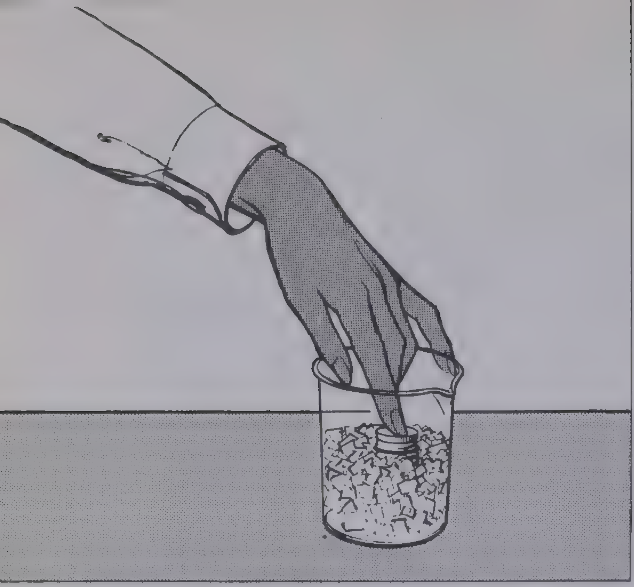
Sumitomo Metal Industries, Ltd.

Josef Muench

Sand, clay, earth, mud—some form of Mother Earth comes into all of these activities. And earth starts with hard rock. No matter where on Earth you dig, sooner or later you reach hard rock.

A. MOUNTAINS WILL CRUMBLE

Where do sand, clay, earth, and mud come from? Rocks don't melt in the sun, but they spend all their time outdoors. What happens to rocks out in the weather? They get wet. They get covered with ice and snow. Plants live and die on them. Forest and brush fires scorch them. All of this must have some effect. Let's see what it is.



Fill the small glass bottle with water. Close it under water so there won't be any bubbles. Place it in a beaker or jar. Surround it with a mixture of salt and crushed ice. Look at the bottle carefully every few minutes.

1. What happens?

2. Did the other group get the same results?

3. What do you think will happen if water gets into tiny cracks in a rock and freezes?

4. If freezing like this takes place high on a mountain, what may happen below?

U.S. Dept. of the Interior Geological Survey

B. DON'T LET THEM GRIND YOU DOWN

Rocks don't do too well when the water around them keeps melting and freezing. Maybe if it were cold all the time things would be better. Or would they? A pile of snow over a hundred feet thick will weigh quite a bit. If it starts sliding down a hill, what happens to the rocks under the snow?

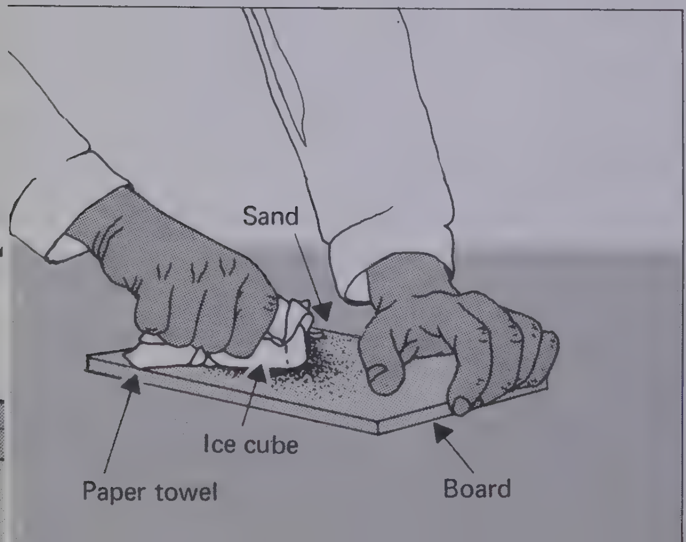
Sprinkle some sand on a board. Use a paper towel to pick up an ice cube. Push the ice cube tight against the sandy board. Drag it along.

5. What happens to the board?

6. Turn the piece of ice over. What has happened to some of the sand?

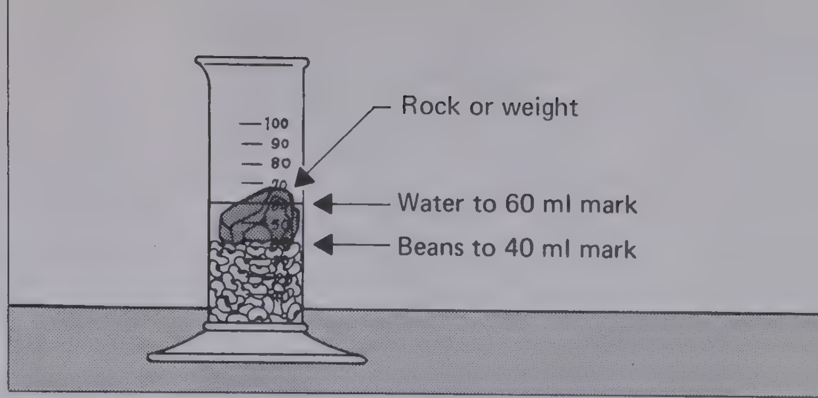
7. What common tool does this remind you of?

8. How do you think this process may affect rock?



U.S. Dept. of the Interior Geological Survey

C. POWERFUL BEANS



What else is rough on rocks? Do plants get into the act? A plant manages to lift itself and grow against the force of gravity. What will it do if a rock gets in its way?

Fill a 100 ml graduated cylinder to the 40 ml mark with dried beans. Use baby lima beans, pinto beans, or other beans of the same size. Rest a piece of rock on top of the beans. Fill the cylinder with water to the 60 ml mark. Measure the distance from the top of the rock to the bottom of the cylinder.

9. Record the measurement.

10. Let the graduate stand overnight. Measure and record the distance from the top of the rock to the bottom of the cylinder again.

11. What happened to the rock?

12. What would happen if it were a bigger rock?

Pushing up a small rock is not a very big job. Suppose a seed falls into a tiny crack in a big rock.

13. What will happen when the seed sprouts into a plant?


U.S. Dept. of the Interior Geological Survey

One large batch of patching plaster will be mixed for the whole class. It should be as stiff as possible.

Take two 1 oz. paper cups and ten beans. (Baby lima beans or pinto beans will work well.) Put all the beans into one cup and pour in wet plaster until the cup is full. Stir up thoroughly with a stick so that the beans are spread around in the plaster.

Fill the other cup with wet plaster without beans. Let both cups set for 24 hours. Peel the paper cup away from each chunk of hard plaster.

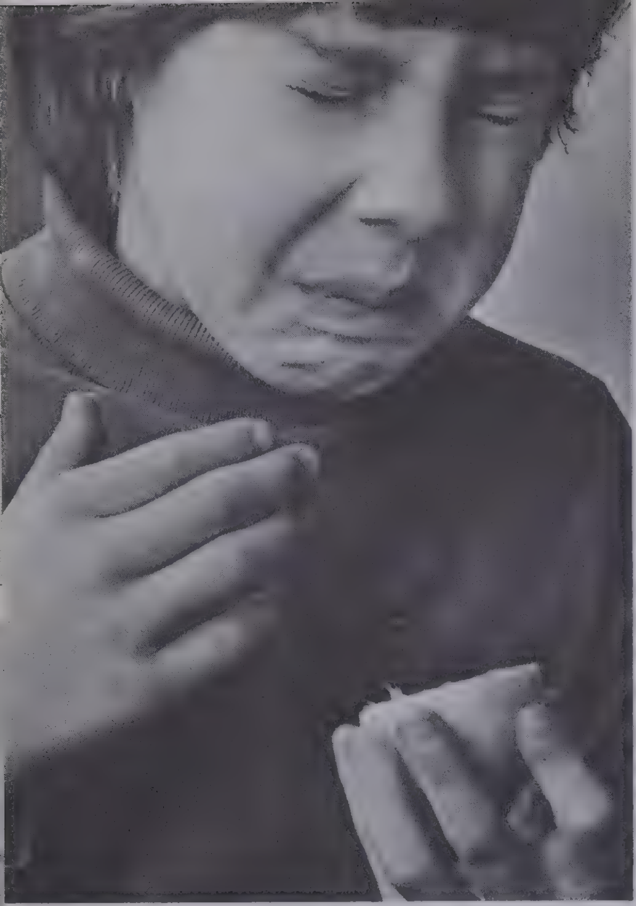
14. Describe the condition of each chunk of plaster.

15. How do you account for the difference between the two chunks?

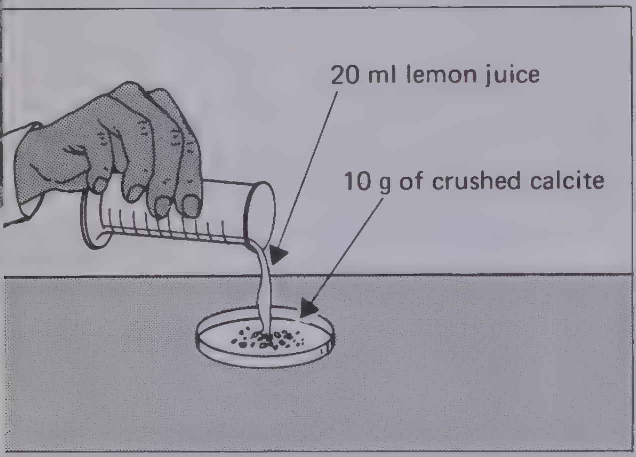
16. When is a tiny plant stronger than a big rock?

D. CHEMICAL WARFARE

Plants can push rocks out of their way. Plants also produce many chemicals. These chemicals seep down to the rock below. Then what happens?



Sybil Shackman from Monkmeyer Press Photo Service



Did you ever try to suck a lemon?

17. How did your teeth feel after tasting a lemon?

How does a rock react to lemon juice? It certainly can't use the vitamin C.

Place about 10 g of crushed calcite in a Petri dish. Pour 20 ml of lemon juice over it. Look closely.

18. What happens?

19. If plant chemicals keep reacting with rock long enough this way, what will finally happen to the rock?

E. THE GOOD EARTH

The formation of soil is very slow. Mountains keep wearing away. Rocks keep coming apart and being washed down into the fertile valleys. It takes about a thousand years to produce an inch-thick layer of soil over the rock.

20. What does it take besides water and rock to keep the soil formation process going?

21. What is interacting to wear down the Earth's surface?

22. Why is soil important to us?

CONCEPT SUMMARY.

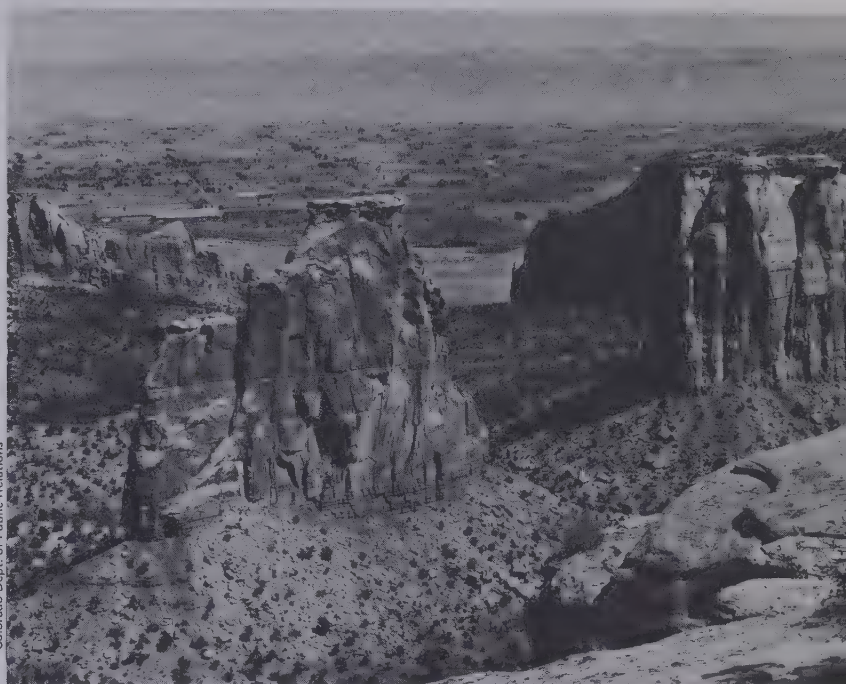
J.C. Allen and Son

Investigation 5

Our Great Big Layer Cake

Interactions in the atmosphere also affect the Earth. The surface of the Earth is wearing down. Rocks crumble. Mountains don't last forever.

This wear and tear leads to questions. What happens to the rock that is worn off? Will the Earth ever be worn smooth? If the Earth is about 4½ billion years old, why isn't there worn-out rock all over the place?

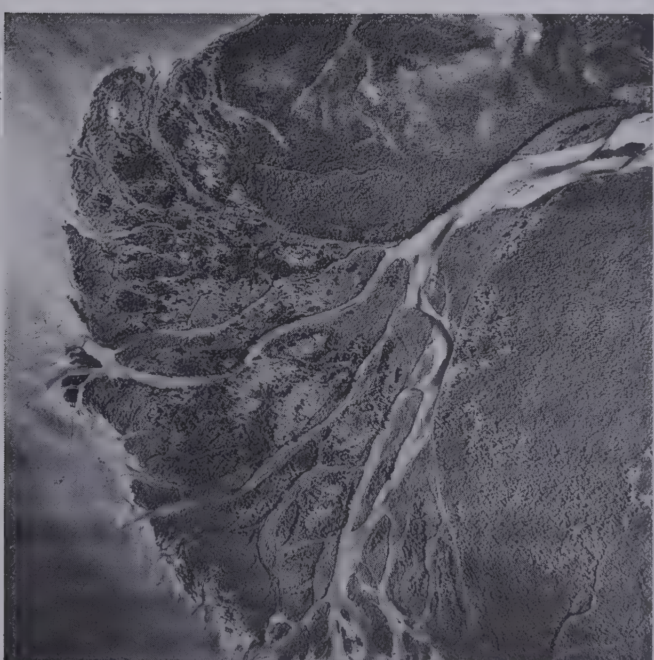


Colorado Dept. of Public Relations

A. THE SALT OF THE EARTH

1. What do you think happens to the worn-off rock?

Water can do many things. It may form rivers and flow off into the sea. It may collect as lakes and ponds. Sometimes a change in weather conditions or climate may cut off the water supply to a lake.



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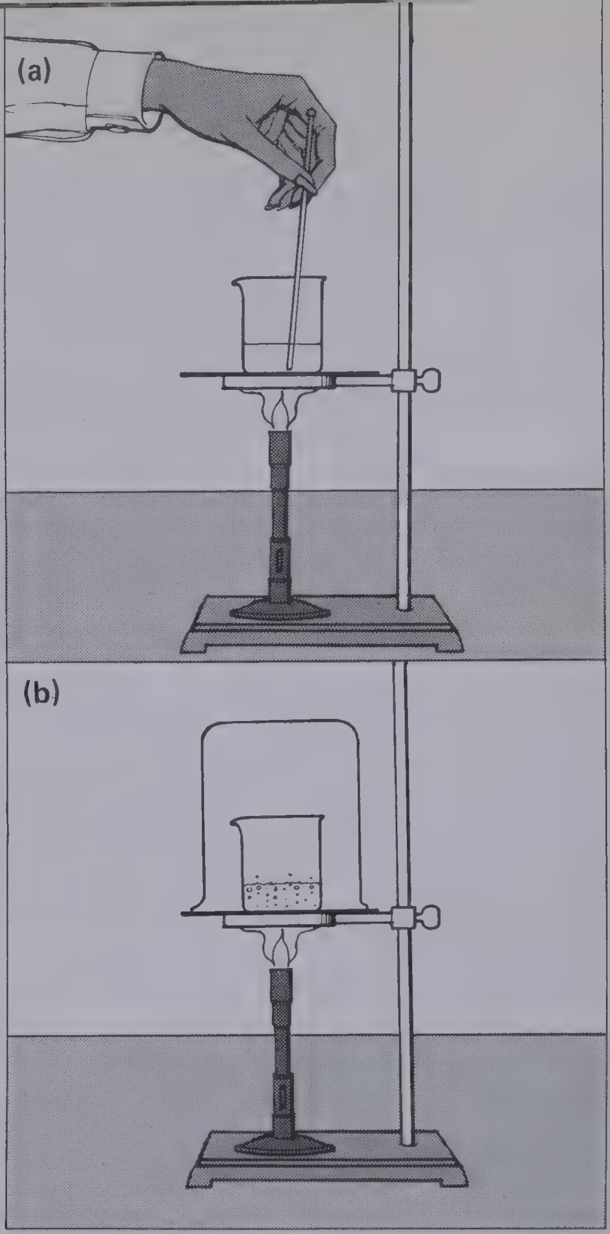


2. What happens to a puddle a day or so after the rain stops?

3. What do you predict will happen to a lake if water stops flowing into it?

Water is always on the move. Whatever is in the water—salt, other chemicals, dissolved rock—is moving too. We are more interested in the things in the water than the water itself. Let's find out what happens to them when the water dries up.

Pour 25 ml of water into a 100 ml beaker. Add ¼ teaspoon of the blue crystals and stir until they are dissolved.

DO NOT TASTE THE BLUE CRYSTALS. THEY ARE POISON.

Place the beaker of blue liquid on the burner stand with the flame underneath. Place a clean 600 ml flameproof beaker upside down on the stand so that the smaller beaker fits up inside it.

Boil your blue liquid and blow on the outside of the large beaker. When enough drops have collected on the inside of the large beaker, shake them together and examine the liquid you have obtained.

4. What color is it?

5. Keep the small beaker over a low flame until the contents are dry. What is left?

6. How do you think the Bonneville Salt Flats in Utah were formed?

B. IF ROCKS COULD TALK

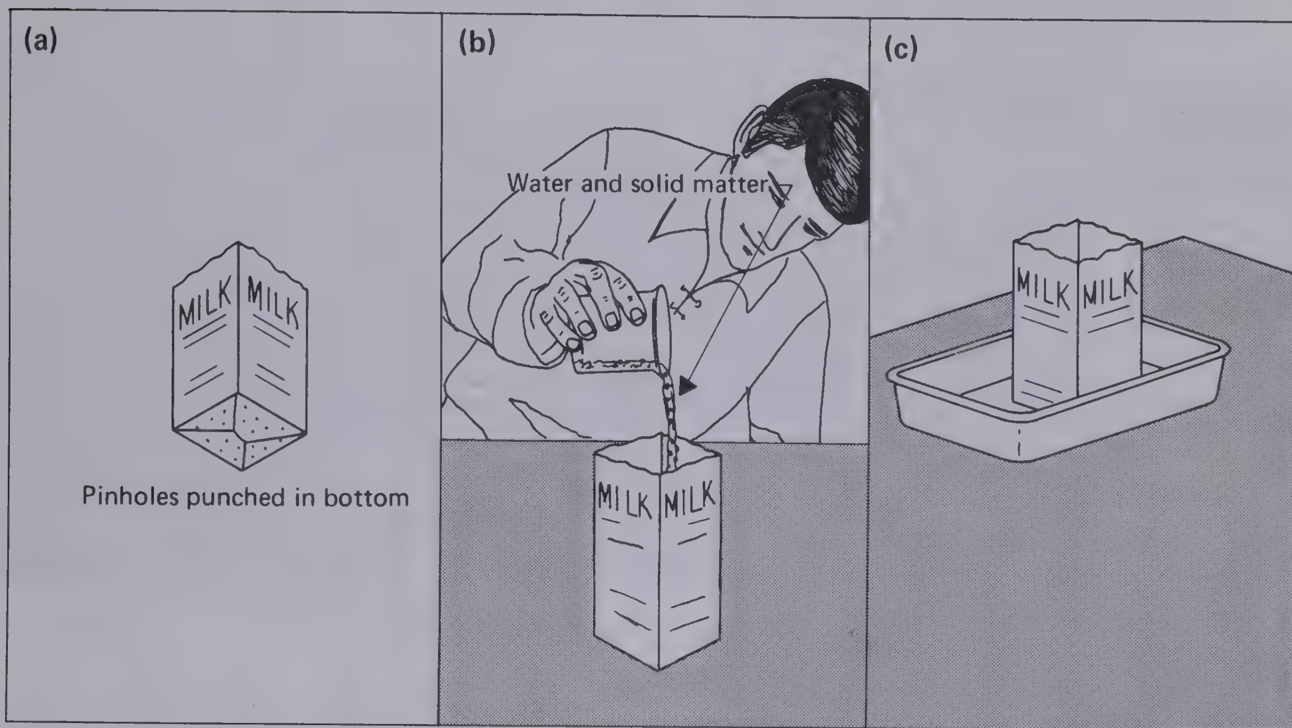
We now have a clue about where some of the worn-out rock is going. At this point some people may be wondering how rocks got there in the first place, before they started to wear away.

7. Examine the rock specimen that will be passed around. Describe what you see.

An artist could chisel designs like that into hard rock with cold tempered steel. But nature doesn't use cold tempered steel.

8. What do you think the rock was like when those designs were put into it? Explain how it might have happened.

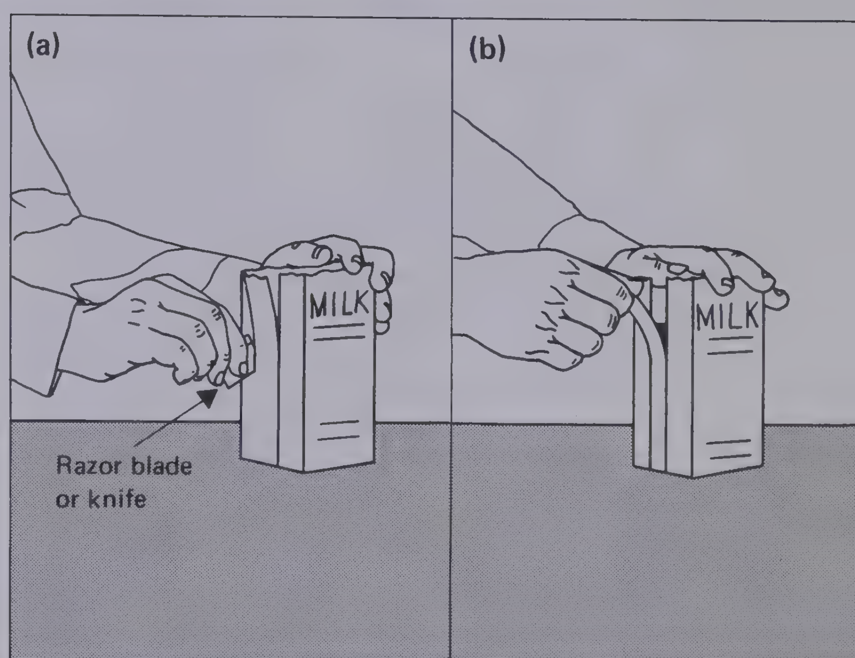
One thing we always look for in nature is order. Let's see if there is any pattern to the formation of rock.



Cut the top off a milk carton. Make a few pinholes in the bottom. In a beaker make up a mixture of about 200 ml of the coarse gravel and water, half and half. Pour it into the carton. Let the carton drain in the sink or in a large pan.

Mix up some fine gravel and water in the same way, and pour it into the carton. Let the water drain out. Follow up with one more mixture: sand in water. Stir well just before pouring into the carton. Let the carton drain overnight after the last mixture.

Cut 2 slits down one side of the carton. Peel down the strip of carton between the slits.



9. Describe what you see.

10. Which layer should be the oldest?

11. Are the layers level or tilted?

12. Which layer would have the oldest fossils if this had happened in nature?

Rock that is wearing off mountains is carried away by water. When the water slows down in lakes or the sea, the rock particles settle out.

13. What may happen to the material that settles out?

C. IT ALL GOES ON UNDERFOOT

New layers of material can be formed from particles that settle out of water. Dissolved minerals remain behind when water evaporates.

14. What has to interact with water to make it evaporate?


U.S. Geological Survey

The formation of new layers depends upon the interaction of three things.

15. One is water; what are the other two?

Some rocks we find today must have been softer at one time.

16. What did a rock in soft, melted form have to lose to get hard?

In all of these actions something is happening to matter.

17. What is needed to make matter act?

CONCEPT SUMMARY.

Investigation 6

Grow Some Rocks

Energy is constantly reacting with matter to pull down the mountains and wear away the surface of the Earth. The same forces tear down the works of man.

Rock Slabs Are Constantly Splitting Off Stone Mountain, Georgia, and Falling to the Bottom

Prof. Sheldon Judson

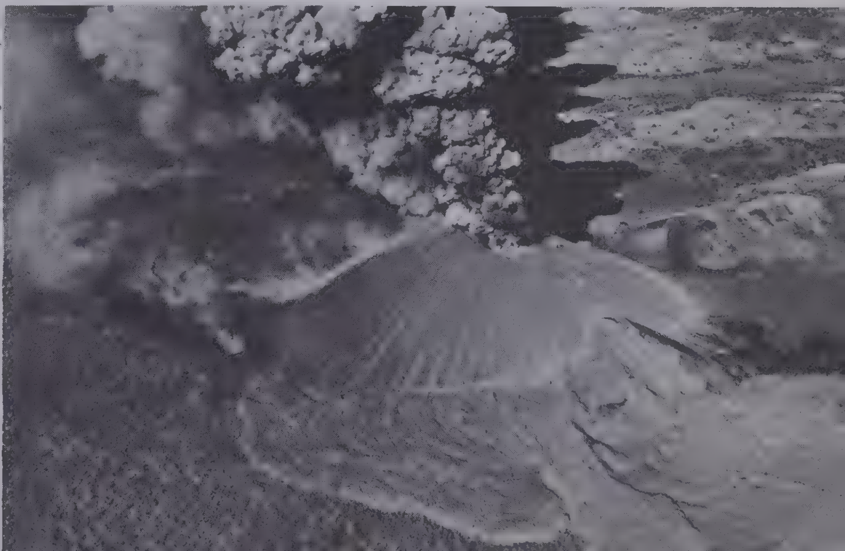
Carbon Dioxide Formed Carbonic Acid in Dripping Rain Water and Wore Away This Building at Harvard University

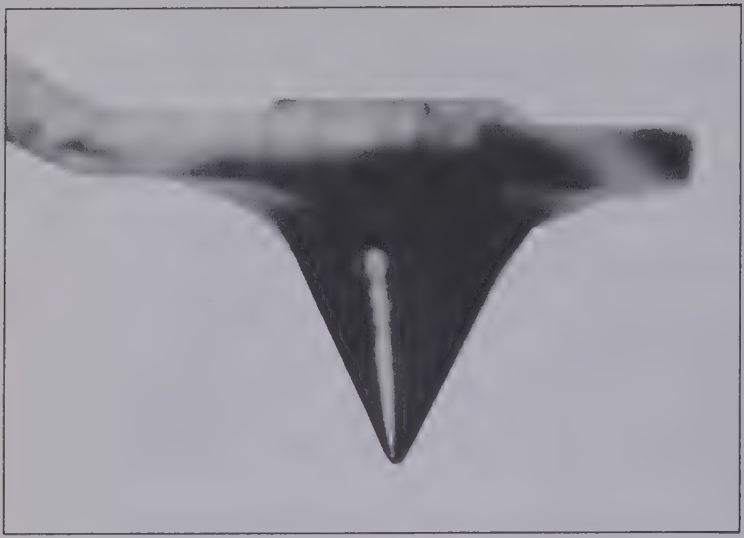
Layers of Sandstone

The last investigation reversed the process. Water and energy washed the worn-off bits of rock and dissolved minerals into lakes and seas. They settled into layers. The layers finally formed rock once more.

Is this all there is to it: rock to mud and sand—mud and sand to rock? Or are there other processes going on in the Earth?

U.S. Geological Survey




Recoton Corp.

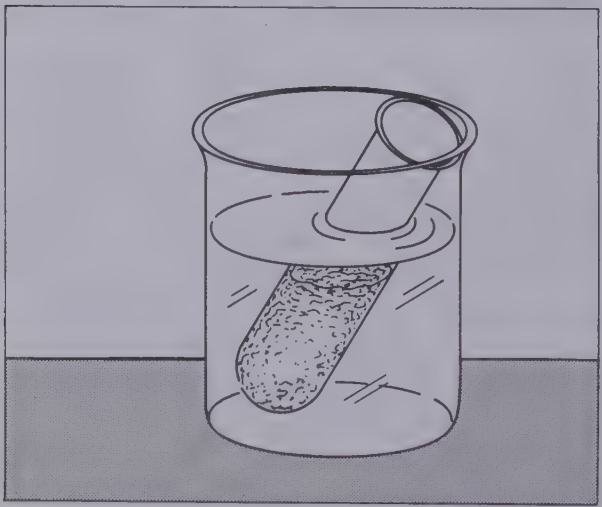
A. TRY IT WET

When you added blue crystals to water and then let the water evaporate, the blue material that remained was also in the form of crystals. Many materials in the Earth's surface are in the form of crystals. Often they are so small or so squashed together that we can't see them. But crystals are everywhere. We see them in the sugar bowl and the salt shaker, in the quartz used in electronic equipment, in diamonds used as decorations, phonograph needles, and industrial cutting tools.

When you talk about crystals, you have to talk about heating and cooling. The blue crystals appeared again when the water evaporated. Suppose the water doesn't evaporate?

Place 50 ml of water in a small flameproof beaker. Add 10 g of potassium sulfate. Warm the mixture over the burner and stir.


Josef Muench



1. What happens?

2. Allow the solution to cool to room temperature. What do you observe?

3. What is being lost as the beaker cools?

4. What did the formation of the crystals seem to depend upon?

B. TRY IT DRY

The temperature of a solution controls the amount of material that can be in solution. This helps decide when crystals will form around hot springs and geysers.

A *solution* usually means a solid material dissolved in water. What if there is no water—will this prevent the formation of crystals?

Fill a test tube about half full of phenyl salicylate. Set it in a beaker of very hot water.

5. What happens?

Take the test tube out of the hot water and let it cool.

6. Describe what you see.

7. What always seems necessary to form crystals? Hint: *not* water.

C. TRY IT MIXED

Water can dissolve many substances. We are interested in what becomes of the minerals dissolved in water. First off, what dissolves in water besides salt?

Among the most common elements in the Earth's crust are sodium (in salt and other minerals); silicon (in sand and most rocks); oxygen (in air, water, sand, and all rocks). When water trickles through the rocks, it dissolves small amounts of different substances.

8. What elements do you think would soon be present in some form in the water?

We will use a solution of sodium silicate, which contains all three of the elements we mentioned: sodium, silicon, and oxygen. Let's see what it does to other mineral substances. Look at the substance nickel sulfate, which we will use with the sodium silicate.

9. Describe its appearance.

Take a quantity of nickel sulfate about the same size as a drop of water. Place it in a beaker or jar with between 50 and 75 ml of water. Stir.

10. Does all of the nickel sulfate dissolve?

Line the bottom of a jar with a paper towel. Fill the jar two-thirds full of the sodium silicate solution. Drop in about 10 or 15 g of nickel sulfate crystals. Let the jar stand for 10-20 minutes. Take out a sample of what you now have in the jar.

11. Describe the substance.

12. How easily does it dissolve in water?

13. Are the properties of the substance the same as the properties of either the nickel sulfate you dropped in, or the sodium silicate that was in the jar to start with?

14. Explain why you think a new substance was formed.

15. What can happen to substances that start out by being dissolved in water?

You have watched solids form in different ways. In two cases no *new* substances were formed. Solids were formed, but the same substances were there before they became solids. In one case, a solid was formed that was a *new* substance.

16. In part A, when you dissolved the potassium sulfate and recrystallized it, what interaction caused the result you saw?

17. In part B, when you melted and rehardened the phenyl salicylate, what interaction caused the result?

18. What two materials reacted in part C to form a new substance?

19. How are the materials of the Earth changed?

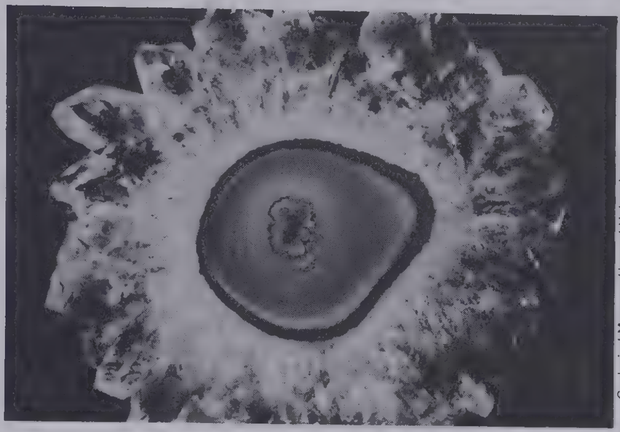
CONCEPT SUMMARY.

Investigation 7

What Goes Down Must Come Up

The weather is the result of interactions of air, water, and energy. After a while water, wind, and energy wear down mountains. Wind and running water spread the worn-off rock out in layers. Chemicals that dissolve in water interact. Some of them act as glue for the new rock layers. Others form crystals of new substances. The layers become rock again.

The worn-down rock collects in low places. The new layers form in lakes and sea bottoms. In 4½ billion years there has been plenty of time for the tallest mountains to be worn down. Why isn't the Earth worn smooth?



Crystals Form in a Bubble in Limestone, Making a Rock Called a *Geode*

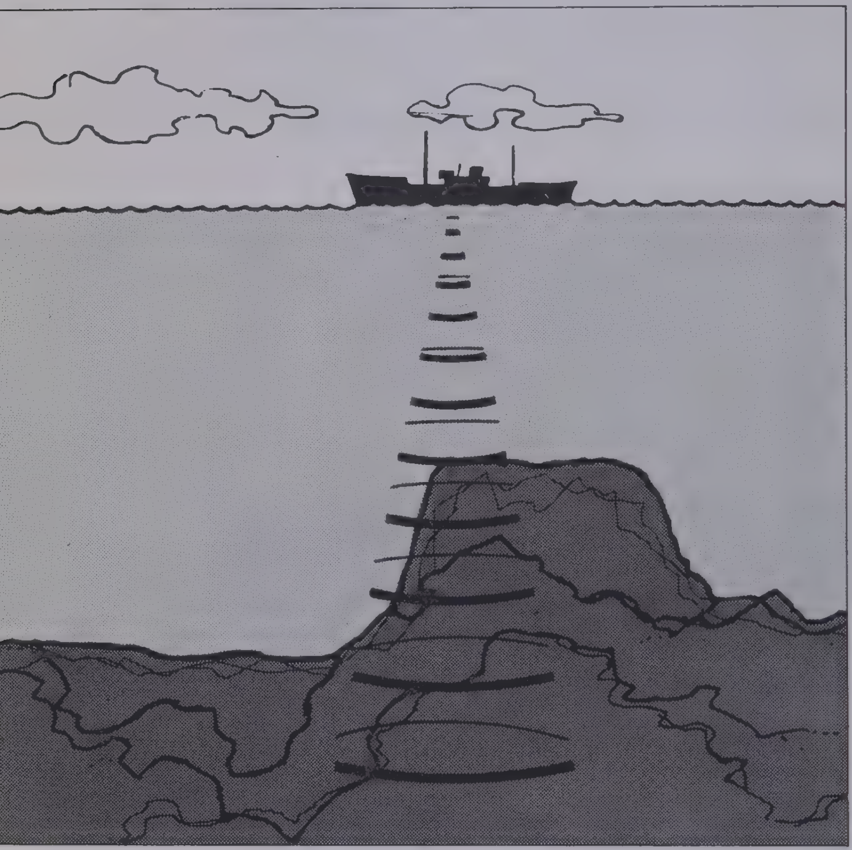
Grand Canyon

A. SURF IN THE MOUNTAINS?

1. The rock specimens you will examine were collected high above sea level. Look at them carefully. Describe what you see.

2. What does the rock specimen tell you about sea level around these rocks a long time ago?

3. What reasons can you give for your answer to question 2?



B. MELT AN ICEBERG

Sonar, a sound-echoing system on ships for detecting submarines, was first used during World War II. The sonar also measured the distance to the bottom of the sea. When certain measurements were collected and examined, whole ranges of mountains were discovered in the sea.

The tops of these mountains are deep below the surface. Samples of them were taken. The samples contained remains of plants and animals that live on land.

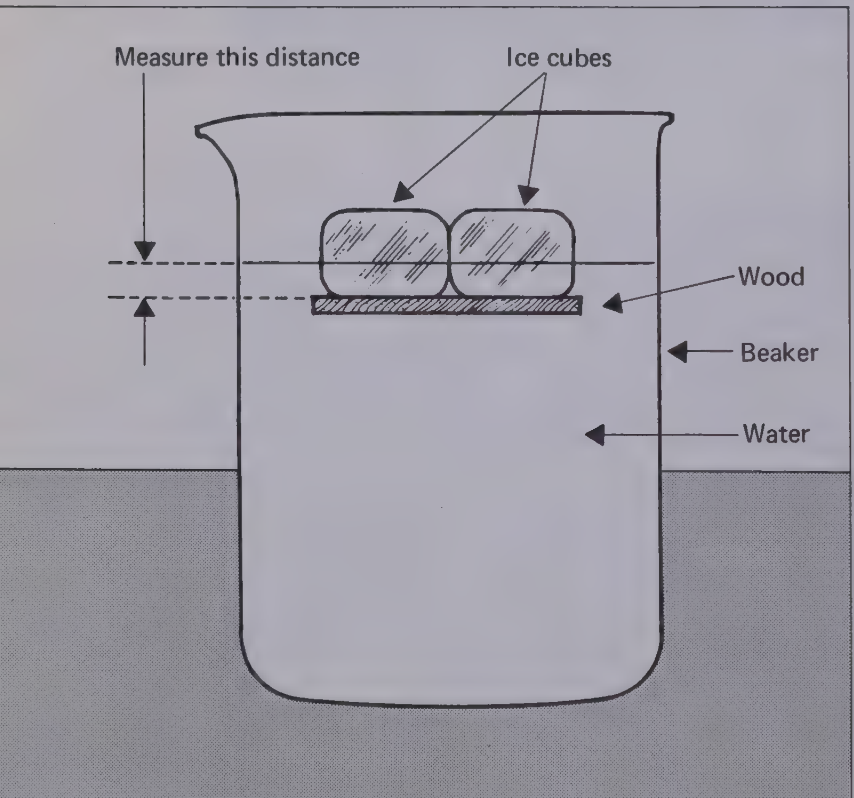
4. What are the possible explanations?

Scientists became convinced that there had once been an Ice Age, during which about ¼ of the Earth's land area was covered with ice hundreds of feet thick. The ice melted back to reach its present position about 11,000 years ago.

5. What do you think happened to the sea when all that ice melted?

6. What do you think happened to the land when the load of ice was taken off?

Place some ice cubes on top of a flat, thin piece of board, just about covering it. Set the board and ice in a beaker of warm water. Measure the distance from the top of the wood to the surface of the water. Record this in the first line of Table No. 1.



7. What happened to the board as the ice melted?

8. What do you think happened to the land under the melting ice of the Ice Age?

9. If the water from the melting ice ran into the sea, what happened to the sea?

10. What do you think the added load of water did to the sea bottom?

C. PUT ON THE PRESSURE

We have seen what happens when the load comes off a surface. What about the opposite action? Melting ice puts a load of water on the bottom of the sea. The rock worn from mountains puts a tremendous load on the lowlands where it collects.

11. What do you predict happens when an increased load is placed on one part of the Earth's surface?

Let's test it. The disk with the special center will be laid flat on the table. The metal cylinder will be set upright on the special center.

12. Record its height above the surface of the disk.

13. After a few minutes have gone by, record the new height of the cylinder above the disk.

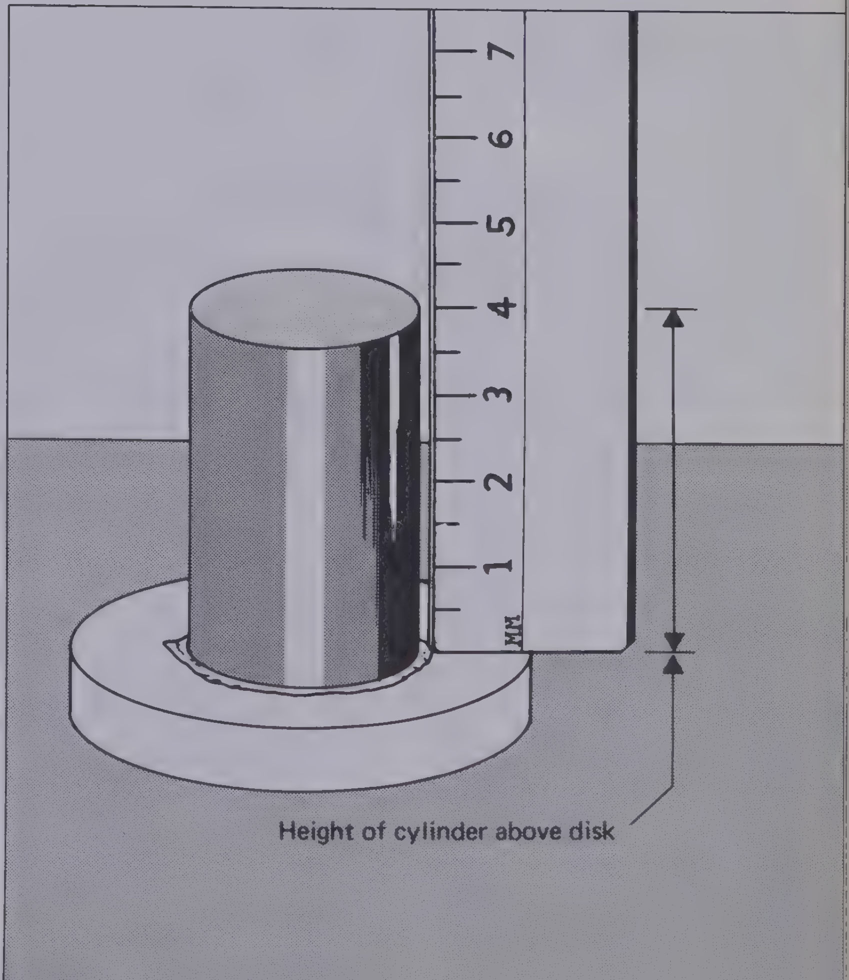
14. What has happened to the cylinder?

15. What happened to the special center in the disk?

16. What happens to an area when a load is placed upon it?

17. What may happen to nearby areas as a result of this?

18. In the light of your answers to questions 8, 10, 16, and 17, what do you think the consistency of the Earth may be like way down below the hard rock in the Earth's crust?



United Press International, Inc.

D. WHEN IT'S GONE, IT'S GONE

There are good reasons for knowing where and when a movement of the earth will take place. Avoiding earthquake damage is one of them. But movements in the earth also have useful effects. The metals we use are sometimes collected into certain places by movements in the Earth's crust.

Max Wyss Is a Scientist Studying Earthquakes

California Institute of Technology

Cars, planes, trains, and cameras all depend on digging these metals from the earth. There are problems. You add to one of the problems every time you take a picture. Even if your camera is all glass and plastic, the film works with silver. To give you the picture, the U.S., in 1965, stopped putting any silver into dimes and quarters; it also cut down the amount in half-dollars. Table No. 2 tells more of the story.

TABLE NO. **2**

SILVER PRODUCTION, IMPORT, AND USE IN THE UNITED STATES*

Year	1930	1940	1950	1955	1960	1963	1964	1965	1969
Produced in United States	50,627	70,436	42,596	37,198	30,766	35,253	36,334	39,808	39,800
Imported	39,177	57,986	79,473	71,168	53,961	67,281	64,395	62,903	39,544
Used in Industry	26,874	44,499	110,000	101,000	102,000	110,000	123,000	137,000	141,516

*Thousands of ounces

19. Add the amount of silver produced in 1930 to the amount imported. Is this more or less than the silver used in industry that year?

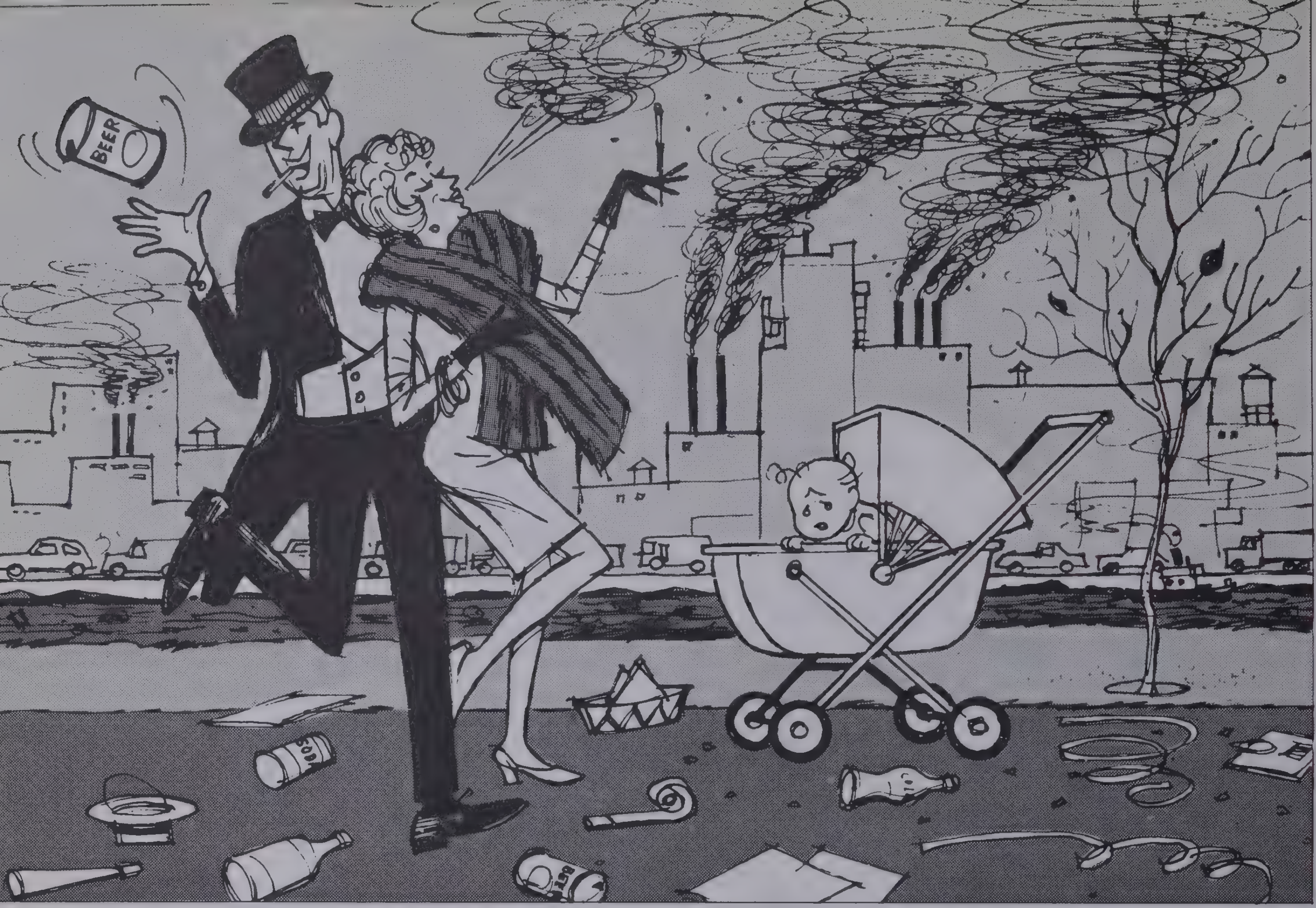
20. Add the amount of silver produced in 1969 to the amount imported. Is this more or less than the silver used in industry that year?

21. What is happening to our supply of silver?

Black Star

Silver and all the other minerals in the earth are natural resources. A country depends on its natural resources to make it go. People depend on them to lead happy, satisfying lives. Some resources are renewable: trees may grow back; water will collect again for power plants. But when a mine plays out, that's the end.

The 100,000 or so people in the photographic industry may be able to find other jobs if the silver goes. But what would the whole country do if the problem were iron or oil? One out of seven jobs depends upon the automobile industry, and running out of iron or oil would stop it cold.



You may have heard statements like: "Don't worry, the scientists will solve everything," and "Live it up today and let our grandchildren do the worrying."

22. Do you agree or disagree with such statements? Why?

There is a lot of action on the Earth. Things are melting or freezing, wearing down or piling up. You have observed what happens when a load is removed. You also saw what happens when a surface is weighted down.

23. Why isn't the Earth worn smooth?

24. What interactions keep things going?

CONCEPT SUMMARY.

Investigation 8

What's Going on Down There ?

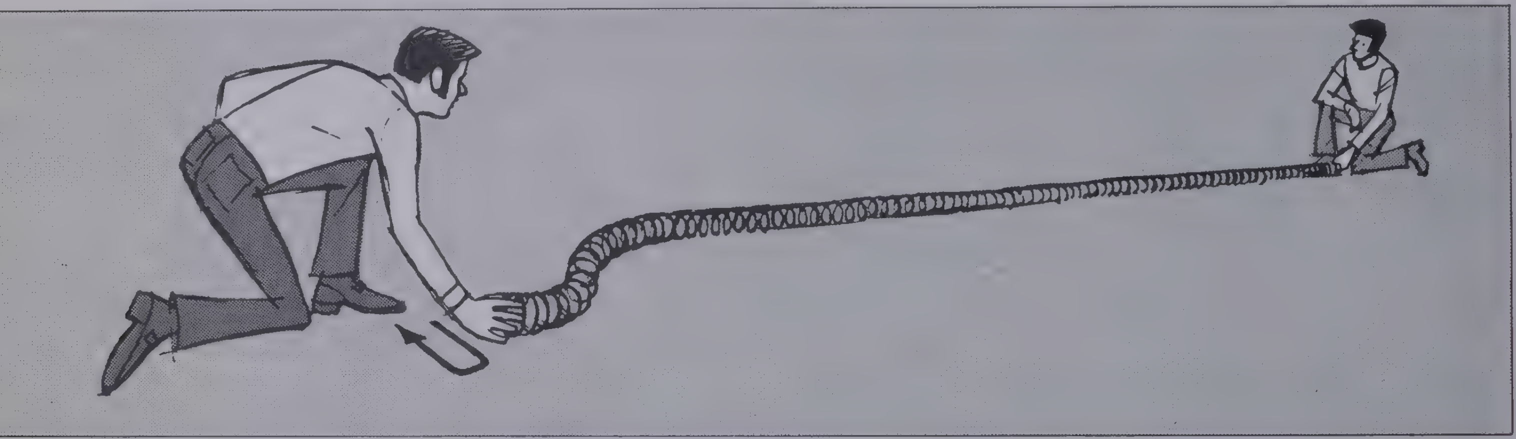
Everything is in action. The weather keeps changing. The elements of the Earth are recombining to make new compounds. Some parts of the Earth are rising while others are sinking. What if an earthquake knocked you off your feet? First you would pick yourself up. Then you would ask questions. What's down there? Is the Earth solid all the way through? Why do houses on soft ground suffer more earthquake damage than those on hard rock?

We get information from inside the Earth in the same way we get information from light and sound in the form of waves. And just like a doctor listening to your chest, or a mechanic listening to your motor, we must first learn how to understand the waves coming from inside the Earth.

A. MY WAVE CAN BEAT YOUR WAVE

All waves have certain things in common. Waves traveling along springs will give us clues about waves in the Earth.

Lay a super-Slinky on the floor and have your partner pull it in a straight line out to at least 30 feet. All of the super-Slinky, including both ends, should be touching the floor. (You may have to go out in the hall to do this one.) Give your hand, holding the end of the super-Slinky, a quick jerk sideways. This sends one kind of wave down the Slinky.

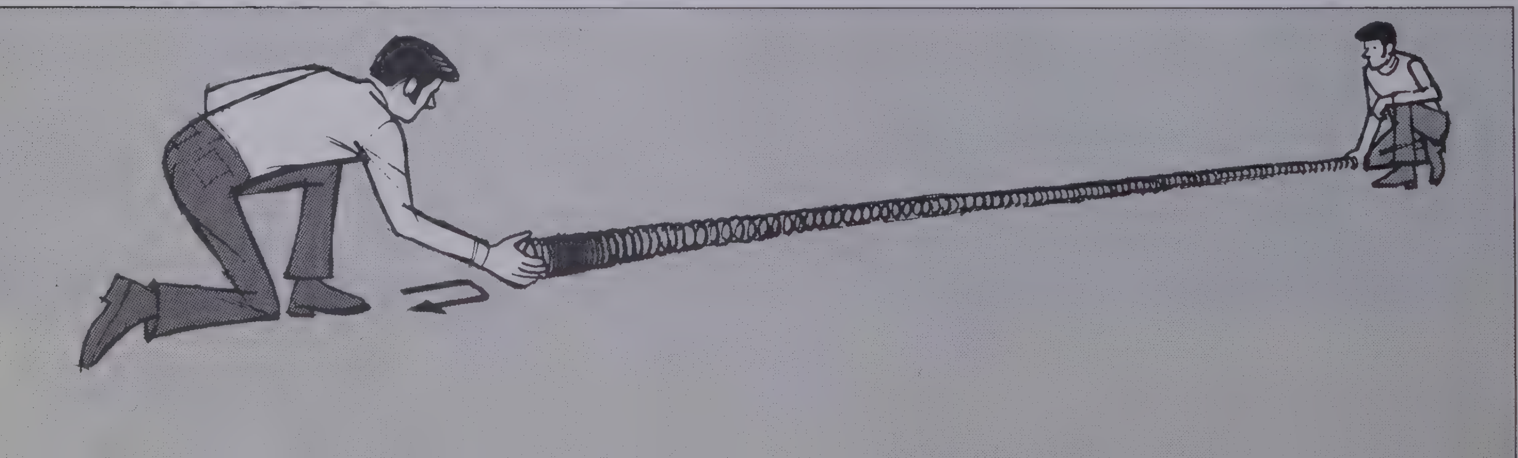


Transverse Wave

1. Describe what you see as the wave goes down to the other end.

This is a crossways or *transverse* wave. Now try another kind of wave. Give your hand, holding the end of the super-Slinky, a quick jerk back and forth. This sends another kind of wave down the Slinky.

Compression Wave



2. Describe what you see as this wave goes down the Slinky.

This second wave is a *compression* wave. Now let's race them.

Get two super-Slinkies, side by side, stretched out straight to the same distance, with your partner holding down both at one end. At exactly the same moment, send a transverse wave down one and a compression wave down the other. (If this is difficult to do alone, you may want another team-member to work with you, and someone to give the signal: "One-two-three.")

3. Which kind of wave got down to the end first?

4. If two such waves start together from an earthquake, how will they be received a short distance away?

5. What will change if they come from a long distance away?

B. GET THE MESSAGE

Telephones, radios, television receivers, and record players all work by converting waves you can't detect into waves you see or hear. In order to study earthquake patterns we must detect the transverse and compression waves coming through the earth.

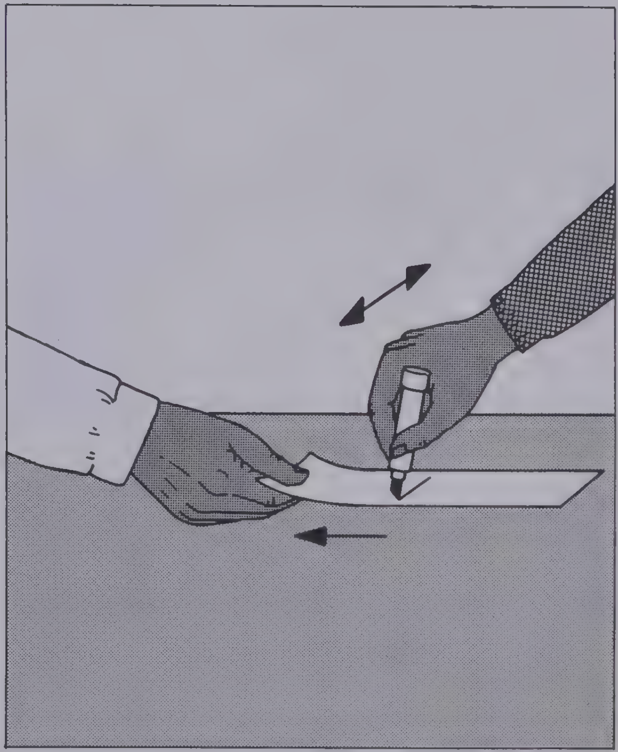
Tie a weight to the end of about a meter of light string. Choose a weight like a lead sinker so you can attach the string at the top center. Hold the end of the string. The weight should hang just off the floor, neither spinning nor swinging. Slowly move your hand from side to side.

6. What does the weight do?

7. Move your hand from side to side quickly. What does the weight do this time?

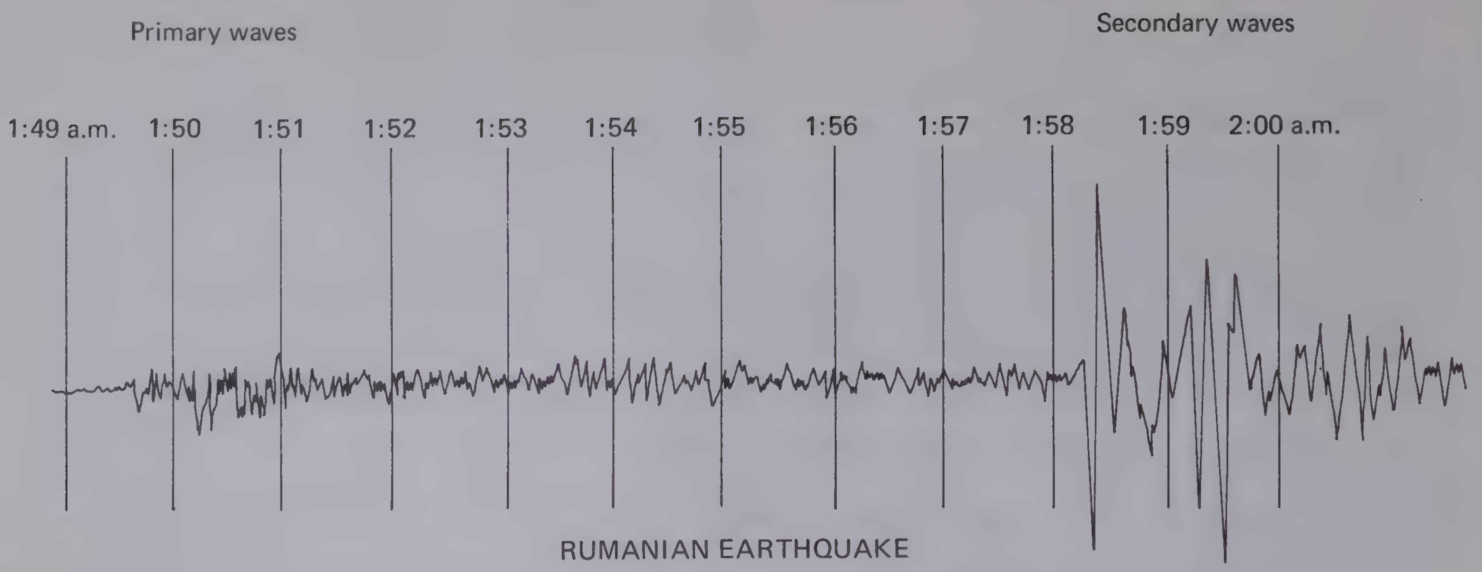
8. If the floor moved sideways, what do you think the weight would do?

Hold a marking pen straight up and down over a piece of paper. Move your hand from side to side slowly as your partner pulls the paper with a steady motion. (Don't try to do both things yourself.)



9. Describe the marks on the paper.

10. Pull the paper at the same speed again. How do the marks change when you move your hand faster?



RUMANIAN EARTHQUAKE
November 10, 1940

The *seismograph* is an instrument that draws earthquake waves. It has a weight, a pen, and a moving strip of paper. It records a wiggly line minute by minute. Just as you got different-looking results when you moved your hand faster or slower, the seismograph shows a picture of the different kinds of waves reaching it.

TABLE NO. 1
SPEED OF PRIMARY AND SECONDARY WAVES

Miles From Source	Time Between Primary And Secondary Waves	
	(Minutes)	(Seconds)
1,000	2	41
2,000	4	52
3,000	6	27
4,000	8	00
5,000	9	25
6,000	10	44
7,000	11	49

You found that compression waves move faster than transverse waves. They have been timed and their speeds compared. The data are in Table No. 1. The faster, compression wave is called the Primary wave. The slower, transverse wave is the Secondary wave.

11. Look at the second column of Table No. 1. How much time was there between the first Primary wave and the first Secondary wave, if the seismograph was 2,000 miles from the earthquake?

12. Look at the record of the Rumanian earthquake of November 10, 1940. When did the big Secondary waves begin?

Estimate the time in minutes and seconds between the beginning of the Primary waves and the beginning of the Secondary waves.

13. What time do you get?

Use Table No. 1 to figure how far the Rumanian earthquake of November 10, 1940, was from the recording station.

14. What distance do you get?

C.E. Rotkin · TEXACO

C. WHAT ABOUT THE REST OF US?

Geologists use earth waves in many ways. They have learned that there are layers of rock deep below the surface where waves move faster than at the surface. They even found a liquid core 1,800 miles down. Oil companies also are interested. So is anyone else who needs metals from the earth.

Another group to come to the geologists for help were government leaders worried about the Nuclear Test Ban. They had to balance the danger of radiation fallout against the plans for national defense. There were problems. Some countries did not like the idea of outsiders coming in to inspect their territory. A way was needed to detect nuclear explosions from a distance.

Some scientists point out that explosion wave patterns are different from those of earthquakes, and that it is possible, with seismographs, to detect even small explosions in caves long distances away.

But other scientists say that once in a while an earthquake occurs with a wave that seems like an explosion. If an explosion is small enough to be hidden in an underground cave, the information that a seismograph far away could give about it would be unreliable.

Where does all this leave the average voter? (Remember, pretty soon the average voter will be you!) Even our lawmakers in Washington are not entirely sure what to do. We could keep testing at the risk of increasing fallout. Or we could stop testing ourselves and maybe miss sneak tests by some other country.

15. Which do you say and why?

Atomic explosions release tremendous energy, but most earthquakes are even more powerful.

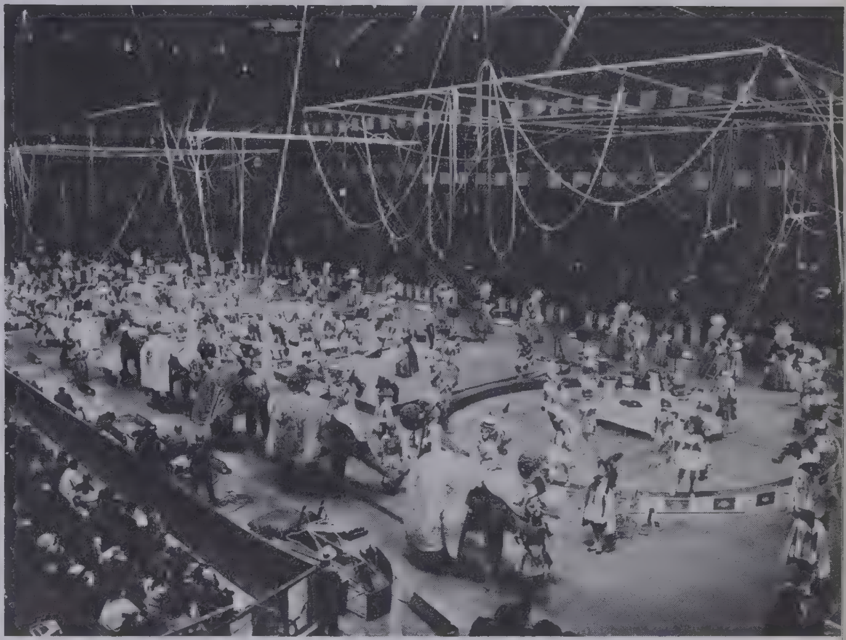
16. What does it take to push millions of tons of rock around?

17. What do the signals received by seismographs during earthquakes consist of?

CONCEPT SUMMARY.

Investigation 9

It Gets Late Too Early


Wide World Photos

Life on earth is like a circus. There is something going on somewhere all the time.

The acts are always changing. Some change quickly, others more slowly. Every performer loves the spotlight, but the spotlight in our circus is also a performer.

A. TURN ON THE HEAT

We don't get the same amount of energy from the sun every day. You find this out in many ways. For instance, part of the cost of living is controlled by the sun. In many parts of the United States gas is used for heating as well as cooking. Table No. 1 shows the amount of gas used in a typical home, each month of the year. (It has been averaged over several years to eliminate unusual weather. Cost has been calculated at the rate of 6½ ¢ per 100 cubic feet.)

TABLE NO. 1
AVERAGE FAMILY GAS CONSUMPTION AND COST, BY MONTH

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Gas Used (in 100 cu. ft. units)	119	105	88	77	53	46	42	33	47	52	86	145
Cost	7.74	6.82	5.72	5.00	3.44	2.99	2.73	2.14	3.06	3.38	5.59	9.40

1. In what month is the gas bill highest?

2. In what month is the gas bill lowest?

3. The difference in cost is due to the amount of sunlight during each month. How much more does gas cost for the most expensive month than for the least expensive month?

4. If you live in an apartment house with central heating, the heating system doesn't work all year round. Explain why.

B. THE SHORTER THE COOLER

If the number of hours the sun shines each day affects the budget, it's worth investigating.

5. What do you predict will come with fewer hours of sunlight: warmer or cooler weather, and why?

Keep a record of the time of sunrise and sunset for a week. If you are not able to time them yourself, get them from a local newspaper or from TV. Record your data in Table No. 2. Fill in the last column.

6. Did you find the hours of sunlight to be increasing or decreasing?

7. Do you expect cooler or warmer weather? Why?

C. FIGURE THE ANGLES

Step outside in December or January, and it is usually cold. Even when the sun is shining, it doesn't seem to have the warmth that it does in July. You found previously that when the angle a light was shining from changed, the temperature of a pan of sand also changed. Maybe the angle the sun is shining from has a connection with the weather. Let's find out.

DANGER —
LOOKING DIRECTLY AT THE SUN WILL DO PERMANENT DAMAGE TO YOUR EYES.


Christa Armstrong from Rapho-Guillumette

The average sunglasses are not enough. You must use a method that doesn't require looking directly at the sun. Let the shadows cast by the sunlight work for you.

8. How long is your shadow at noon compared to 8:00 A.M.?

9. Would you predict that your shadow would be the same length or different, at noon on January 1 compared to noon on July 1?

Choose a time of day, such as noon, 2:00 P.M., 4:00 P.M., etc. At exactly this time each day, measure the distance in centimeters from the bottom of your school flagpole (or some other upright, fixed pole) to the tip of its shadow. Write this distance in Table No. 3 for 7 consecutive days. Fill in the time in the title of Table No. 3.

dpi ~ Grete Mannheim

10. Did the shadow become longer or shorter?

11. Was the sun's position higher or lower each day at the time you measured?

12. Would you expect cooler or warmer weather?

D. WHAT, DARK ALREADY?

During part of the year the days are short. At other times there are more hours of sunlight than of darkness.

13. Which month has the shortest days?

14. Which month has the longest days?

Look at the map of average January temperatures.

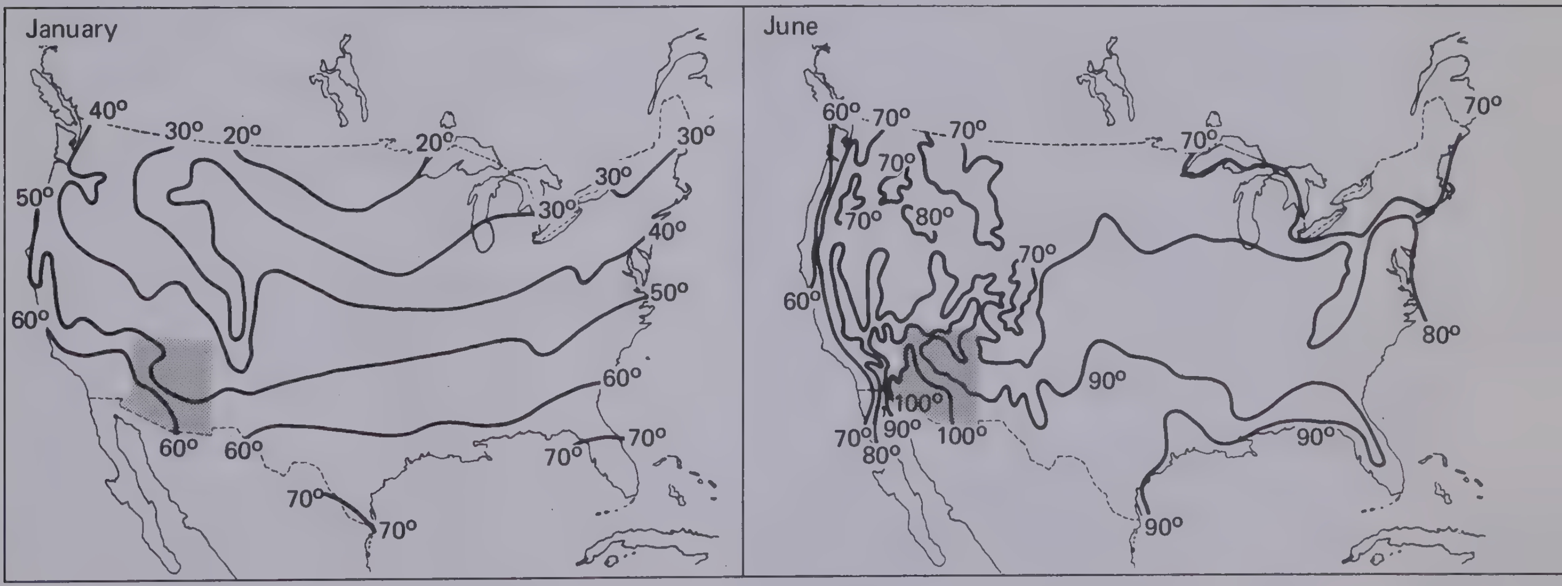
15. What is the freezing point of water?

16. How much of the U.S. stays below freezing in January?

Look at the map showing the highest average June temperatures. Remember, 70°F is considered a comfortable room temperature.

17. According to the map, what is the coolest part of the United States in June?

18. What is it like northwest of Tucson, out in the Arizona Desert, in June?



Canadian Consulate General

Texas Highway Dept.

19. Look at both maps. Where does the sun reach a higher angle, at the Canadian border or the Mexican border?

20. When is the sun at a higher angle, in June or January?

You now have data about energy and the angle of the sun. Is there a pattern?

TABLE NO. 4
SUNRISE AND SUNSET TIMES FOR SAN FRANCISCO

Date	Sunrise (A.M.)	Sunset (P.M.)
Jan. 1	7:25	5:02
Feb. 1	7:14	5:33
Mar. 1	6:42	6:03
April 1	5:55	6:32
May 1	5:14	7:00
June 1	4:49	7:26
July 1	4:51	7:35
Aug. 1	5:13	7:19
Sept. 1	5:39	6:39
Oct. 1	6:05	5:53
Nov. 1	6:35	5:11
Dec. 1	7:06	4:51

Table No. 4 lists sunrise and sunset times for the first day of each month in San Francisco. On the data sheet, fill in Table No. 4a showing the hours of daylight for each of these days in San Francisco.

Now draw a line graph showing the information you have in Table No. 4a. Connect the points on your graph with a smooth line.

21. Describe the shape of your graph.

22. Explain the yearly pattern of hours of daylight.

CONCEPT SUMMARY.

Investigation 10

Somewhere in Space

Man has studied the sun, moon, and planets since the beginnings of civilization. One thing that has always fascinated him, and is even more vital today, is summed up in the question "How far?" In order to figure the time it takes a spaceship to go to the moon you must know two things: the speed of the spaceship and the distance to the moon.

British Crown Copyright

Stonehenge, in England, Was an Ancient Astronomical Observatory

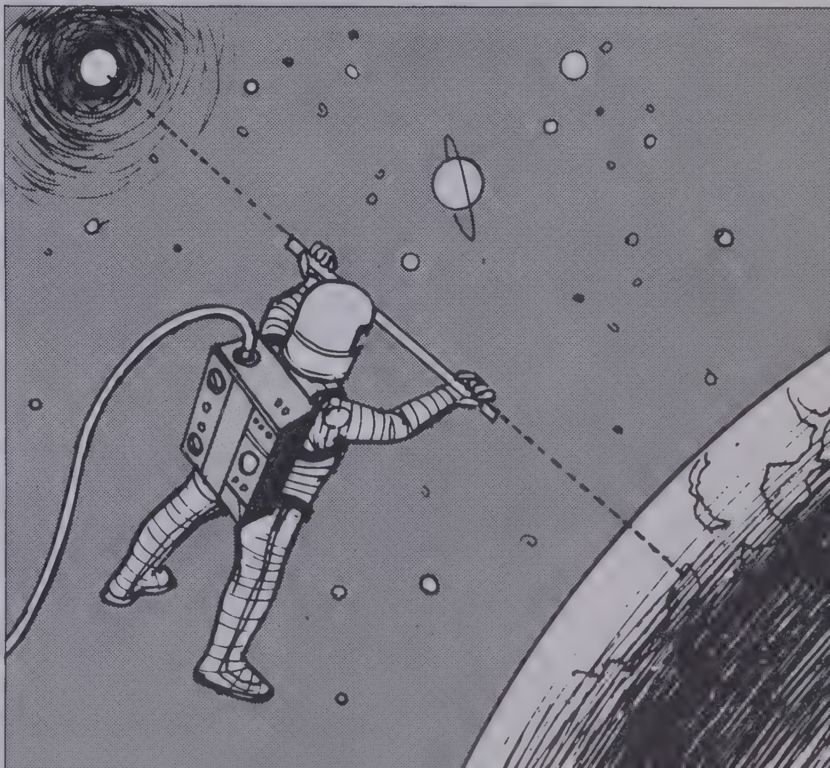
NASA

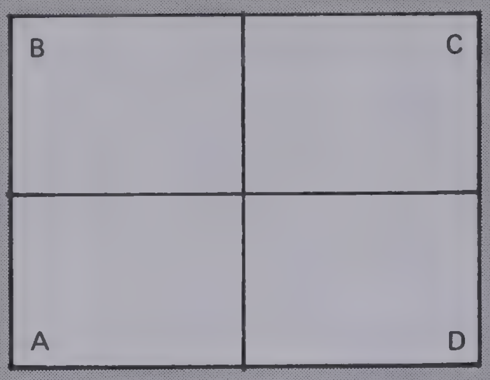
If you ask people how far away the moon is, quite a few may say, "About 240,000 miles," which is right. But how do we know? Our astronauts never took the time to measure it.

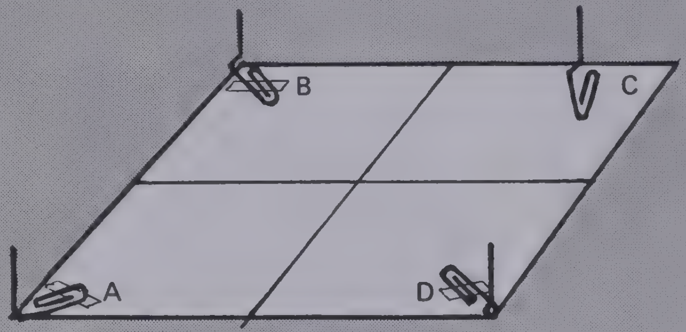
A. HOW HIGH THE MOON?

Have a member of your team look at a pencil which is held near his nose. Have him look at the pencil as he gradually moves it straight out from his nose. While he moves it away, watch his eyes.

1. Do your team member's eyes become more cross-eyed as the pencil is moved straight out from his nose?







Change places, so that you both have the chance to watch each other.

You can get some idea about how far away an object is by seeing how cross-eyed you must be in order to look at it. The nearer it is, the more cross-eyed you must look at it.

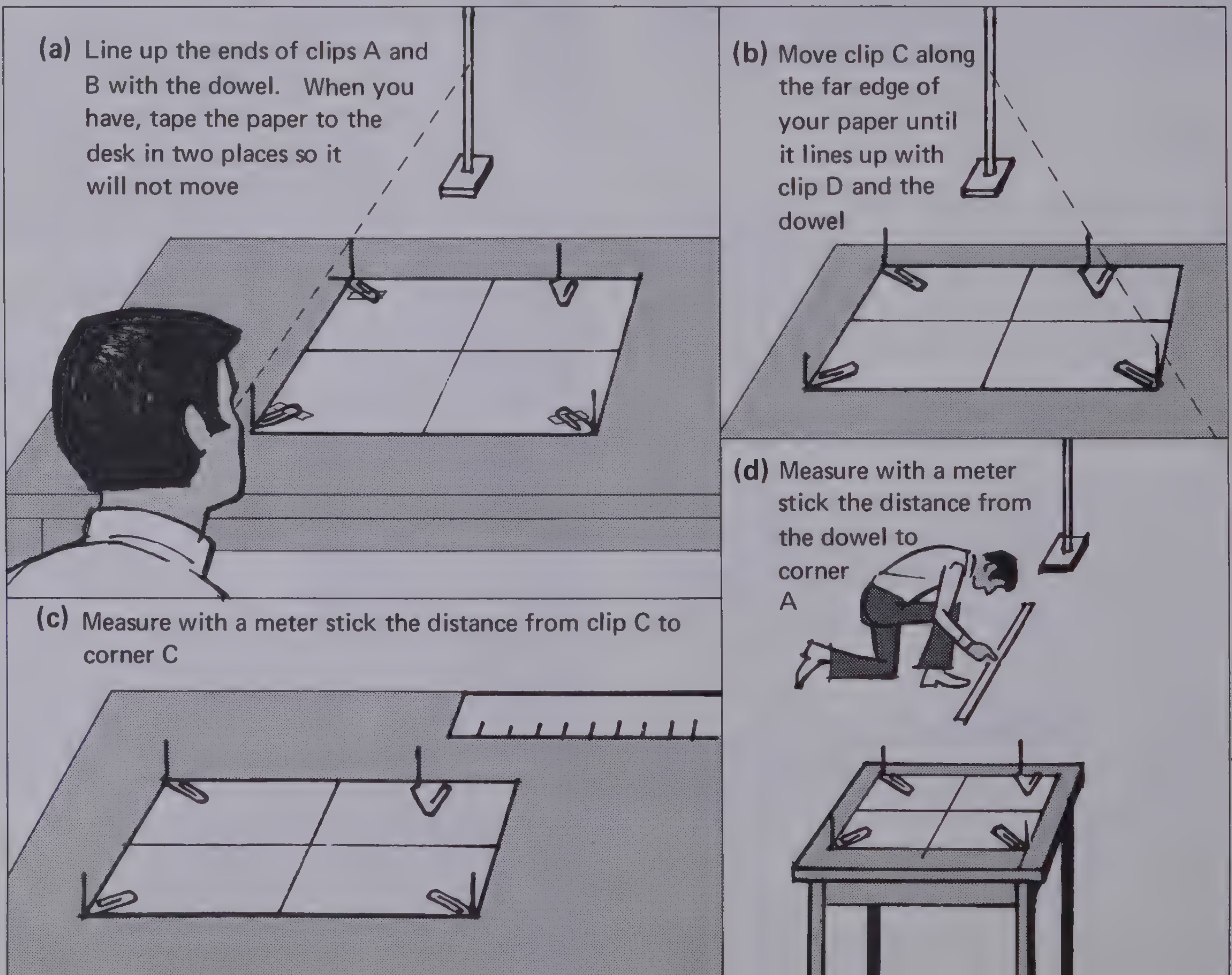
We will now make a distance-measuring device that works something like your eyes.

Tape together 4 pieces of paper or use one large sheet about 20 inches by 15 inches. Label the corners A, B, C, and D as shown.

Tape paper clips to corners A, B, and D but not to C. Get the upright part of the paper clip as near to the corner as you can.

Place a paper clip on the paper near corner C, but do not tape it down.

Put your wooden dowel marker out in front of you near the far wall.



(a) Line up the ends of clips A and B with the dowel. When you have, tape the paper to the desk in two places so it will not move

(b) Move clip C along the far edge of your paper until it lines up with clip D and the dowel

(c) Measure with a meter stick the distance from clip C to corner C

(d) Measure with a meter stick the distance from the dowel to corner A

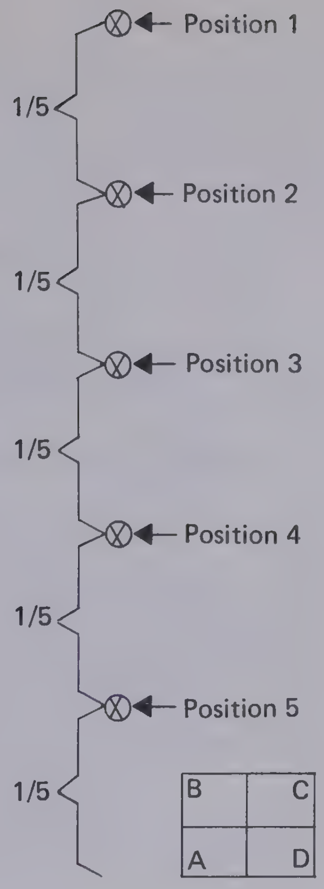
Fill in the first line of Table No. 1 in your data sheet.

Bring the dowel in toward you 1/5 of the distance it is from you. Repeat steps (a), (b), (c), and (d) and fill in the line for Position 2 in the table.

Bring the dowel in toward you another 1/5 of the distance, repeat steps (a), (b), (c), and (d), and fill in the line for Position 3 in the table.

Bring the dowel in another 1/5 the distance, repeat the steps, and fill in the line for Position 4 in the table.

After bringing in the dowel again, repeat the steps, and fill in the line for Position 5. From your table complete the graph on your data sheet.



You have now made for yourself a distance-measuring device called a range finder. From scientific supply companies you can buy range finders ready made. These store-bought range finders are made of solid materials like wood, metal, and glass—and they are expensive.

Let's measure some distances with the range finder you just made.

Place the wooden dowel somewhere in front of you, but don't measure to see how far away it is. It should be farther than your arm's reach, but not farther than the longest distance you had it set at when you were filling in the table.

When the wooden dowel is in place, do steps (a), (b), and (c). Fill in the space for Position 6 in the table, using your graph to get the distance from the dowel to corner A.

2. With a meter stick or tape measure, measure how far away the dowel is from corner A. What do you get?

Canadian Consulate General

3. Now you have two distances to work with: (1) the dowel's distance as taken from your graph and (2) the dowel's distance as measured by your meter stick or tape measure. Subtract the smaller of these two numbers from the larger. What did you get?

4. Do you feel your range finder gave you an accurate answer? Explain.

Move the dowel to a new spot. Do steps (a), (b), and (c), and fill in the space in the table for Position 7. Use your graph to get the distance from the dowel to corner A.

5. Measure the distance of the dowel from corner A, using a meter stick or tape measure. How far is it?

6. You now have two distances: (1) the dowel's distance as taken from your graph and (2) the dowel's distance as measured by your meter stick. Subtract the smaller of these two numbers from the larger. What do you get?

7. Do you feel the range finder gave you a good measurement? Explain.

8. What would you do to make a range finder which was more accurate than the one you have now?

9. Range finders have been made which measure distances much greater than the length of a classroom. When might you use a range finder instead of a meter stick or tape measure?

B. YOU CAN'T GET THERE FROM HERE

The range finder is only one way to measure distance. Try comparing light waves from different distances. Hold your pencil straight up and down, touching your nose. Open your right eye. Close it and open your left eye.

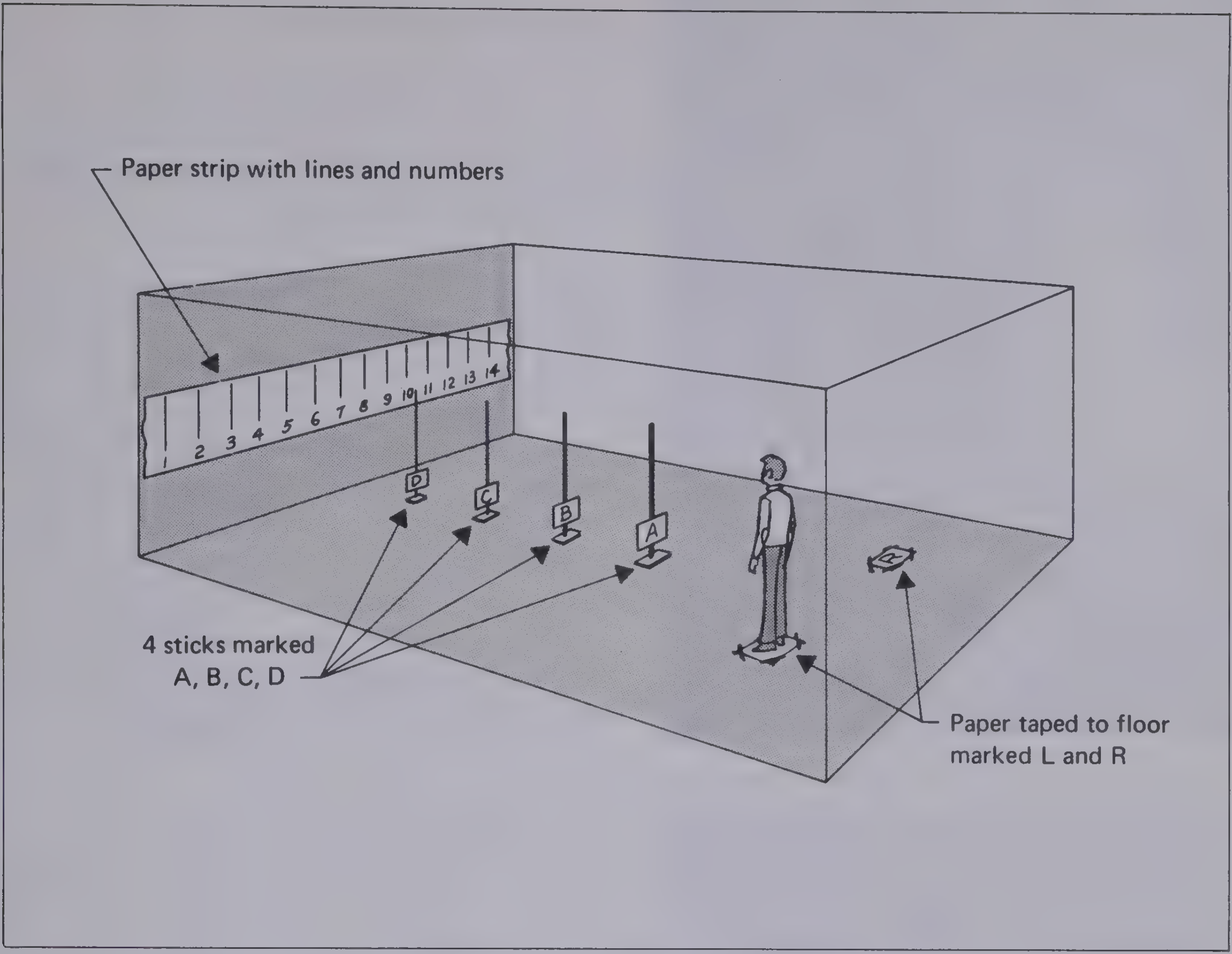
10. What seems to happen to the pencil as you change eyes?

11. Hold your pencil out at arm's length and try switching eyes again. How much change do you see this time?

12. What is really moving—the pencil, the background, your eyes, or nothing?

This effect is called *parallax*. You can use it to find the distances to the stars. The classroom will be your galaxy.

A series of numbered, vertical lines will be drawn at one end of the room, equally spaced across the wall. Four targets (upright poles marked A through D) will be spaced down the center of the room. Target D is the closest to the vertical lines; Target A is at the other end. Two spots will be marked on the floor beyond Target A at the front of the room. Call them R and L. R stands for Right; L stands for Left.



Measure the distance from each of the four targets to a point midway between R and L. Record these distances in Table No. 2.

Stand on R. Close one eye and look at each target in turn. See which numbered line on the back wall is directly behind the target. In Table No. 3, write that number under the target letter for Position R.

Do the same thing for Position L, and record. For each target, subtract the smaller line number from the larger one. Record the differences in the bottom row of Table No. 3. These are the number of spaces each target seemed to move.

Make a line graph to display your data. Have the target distances from Table 2 across the bottom and the parallax (the bottom row of Table 3) up the side.

13. What was the parallax for Target A, the nearest?

14. What was the parallax for the farthest target?

15. Using the graph, how do you find a target distance if you only know the parallax?

16. If a target were right on the base line (L-R line) what would its parallax be?

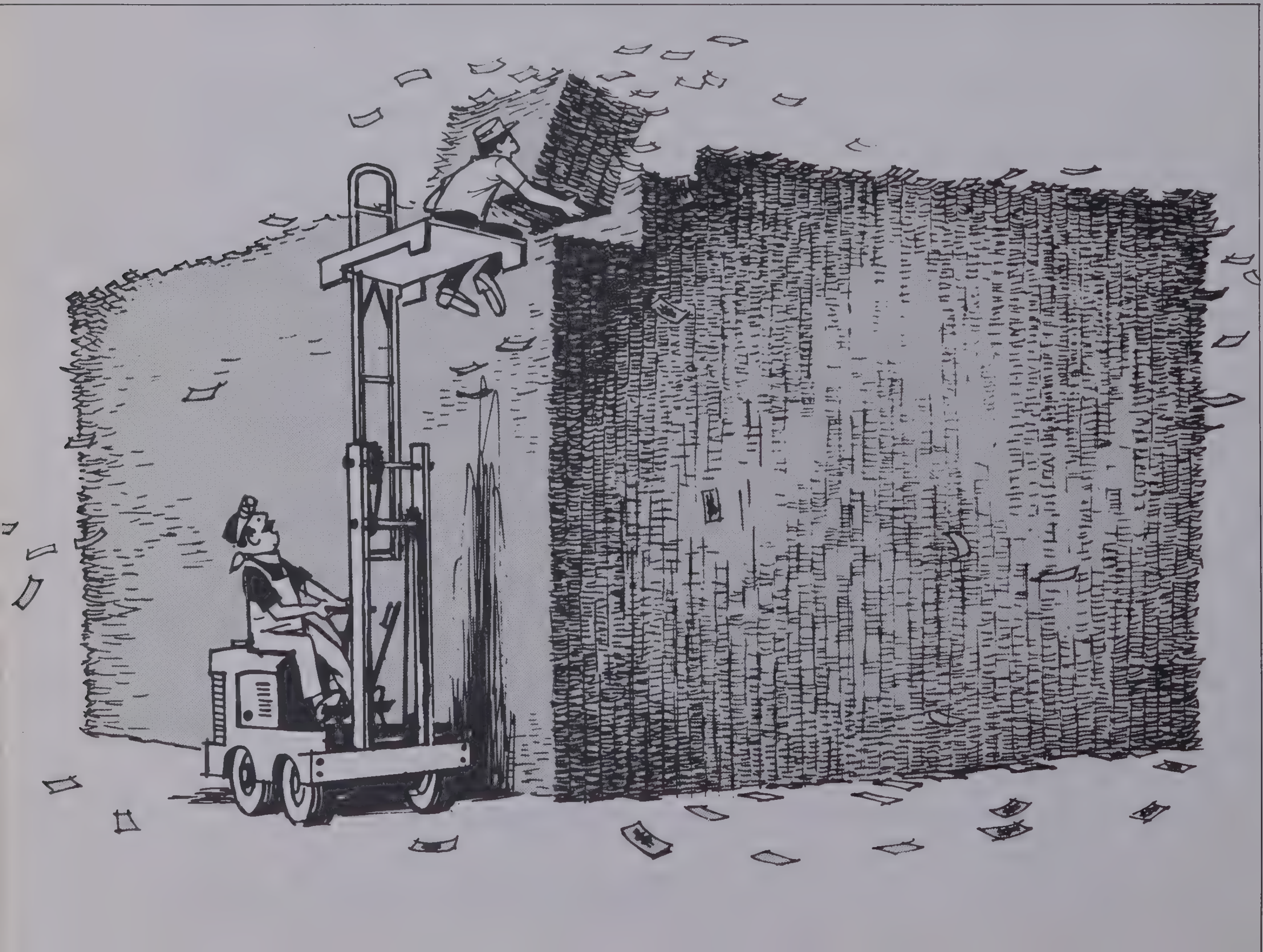
Unmanned Weather Satellite (ESSA 6—Nov. 1967)

C. COUNTDOWNS ADD UP

Astronauts returning from space know how far they went and why they went there. But not everyone knows. Not everyone is happy about the space program.

Every time a space rocket is launched from Cape Kennedy it uses energy as fast as all the machines in a couple of states.

That's a lot of energy, and it's not free. All of the money comes from Federal taxes. Two or three cents out of every tax dollar go into the space program, which spends five billion dollars a year. In numbers this is $5,000,000,000. That's a lot of dollars. In one-dollar bills it would fill a warehouse 30 yards long by 30 yards wide, with a 28-foot ceiling.



Many people say that this money should be spent on better housing and education right here on the ground. Table No. 4 compares these different kinds of expenditures over the years.

TABLE NO. **4**

FEDERAL EXPENDITURES ON VARIOUS PROGRAMS IN RECENT YEARS

Program	Dollars in Millions							
	1955	1960	1963	1964	1965	1966	1967	1968
Space Research and Technology	74	401	2,552	4,171	5,093	5,933	5,600	5,300
All Housing Programs	136	122	67	80	104	890	890	1,023
All Education Programs	377	866	1,244	1,339	1,544	2,834	3,304	2,816
Economic Opportunity Programs	–	–	–	–	211	1,018	1,580	1,860

17. What was the biggest amount spent in 1955?

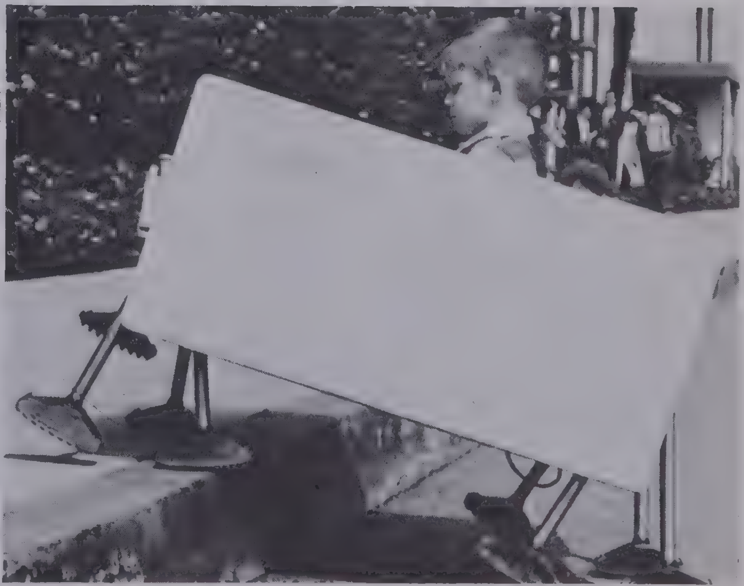
18. What was it in 1968 ?

Spending for housing in 1968 was about seven times what it had been in 1955 (7x136 =952, which is close to 1,023).

19. Spending for Space Research and Technology in 1968 was about how many times what it had been in 1955?

The picture is not all one-sided. Discoveries made in preparing for space travel may be of value to everyone. Here are some examples. Satellite photography helps develop crop lands and mineral deposits. Methods of reading satellite pictures teach doctors to get more information from X-ray pictures. Satellites can detect tiny fires before they become big forest fires. A moon-walking machine helps crippled children here on Earth.


U.S. Forest Service


NASA

Systems for sterilizing spacecraft have been used effectively in hospitals to prevent the spread of infectious diseases.

20. How do you feel about the money spent on the space program when so many things are hurting at home?

D. THE MOON IS RIGHT THERE

You have learned two ways of measuring distance. One is by viewing the unknown in relation to known objects in the foreground. The other is by viewing the unknown in relation to known objects in the background.

21. Both ways use light waves, which are a form of what?

CONCEPT SUMMARY.

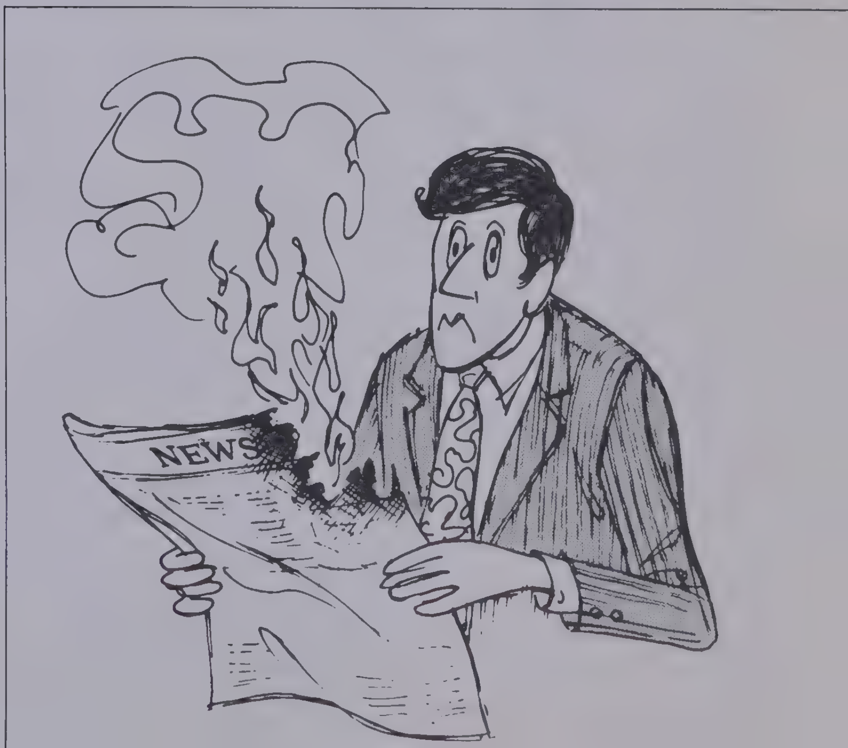
Investigation 11

The Stars Tell All

To find objects in space you use the energy waves the objects give out. Energy explains our whole, changing world. It interacts with matter to produce rain forests and dry deserts, to build mountains and wear down mountains, to make valleys and canyons.

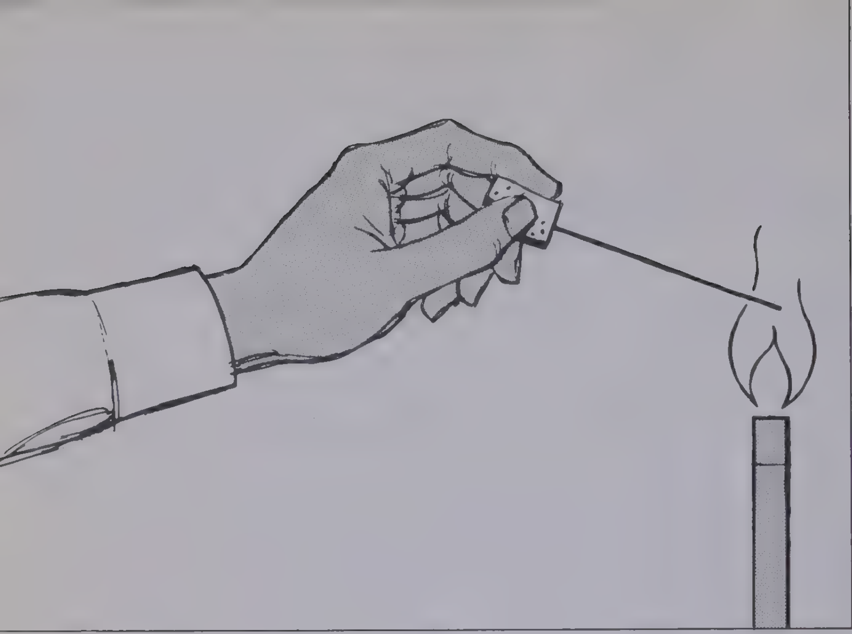
Energy waves carry information. Light energy is used to measure the distance to our sun. We can feel the heat energy of the sun just by standing outdoors on a summer day. When it gets too bad, we find ways to cool it. What about the stars, which are all "suns"? You can't feel starlight, yet scientists think that the stars are hot. Why?

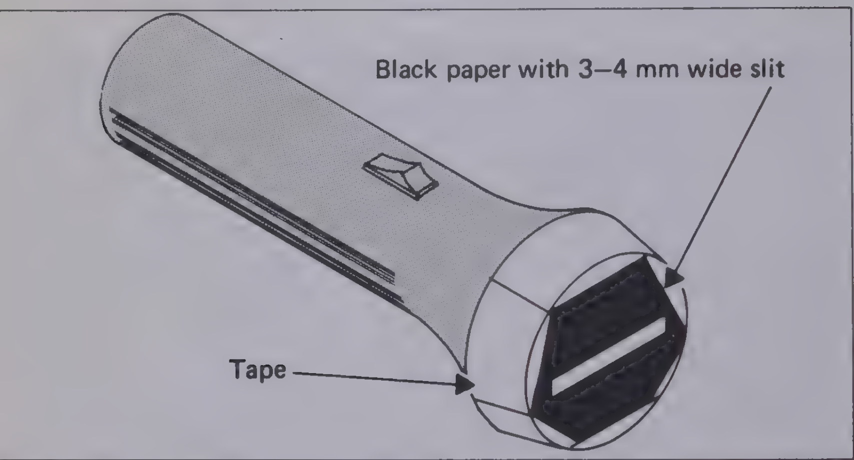
Jim Jowers from Nancy Palmer

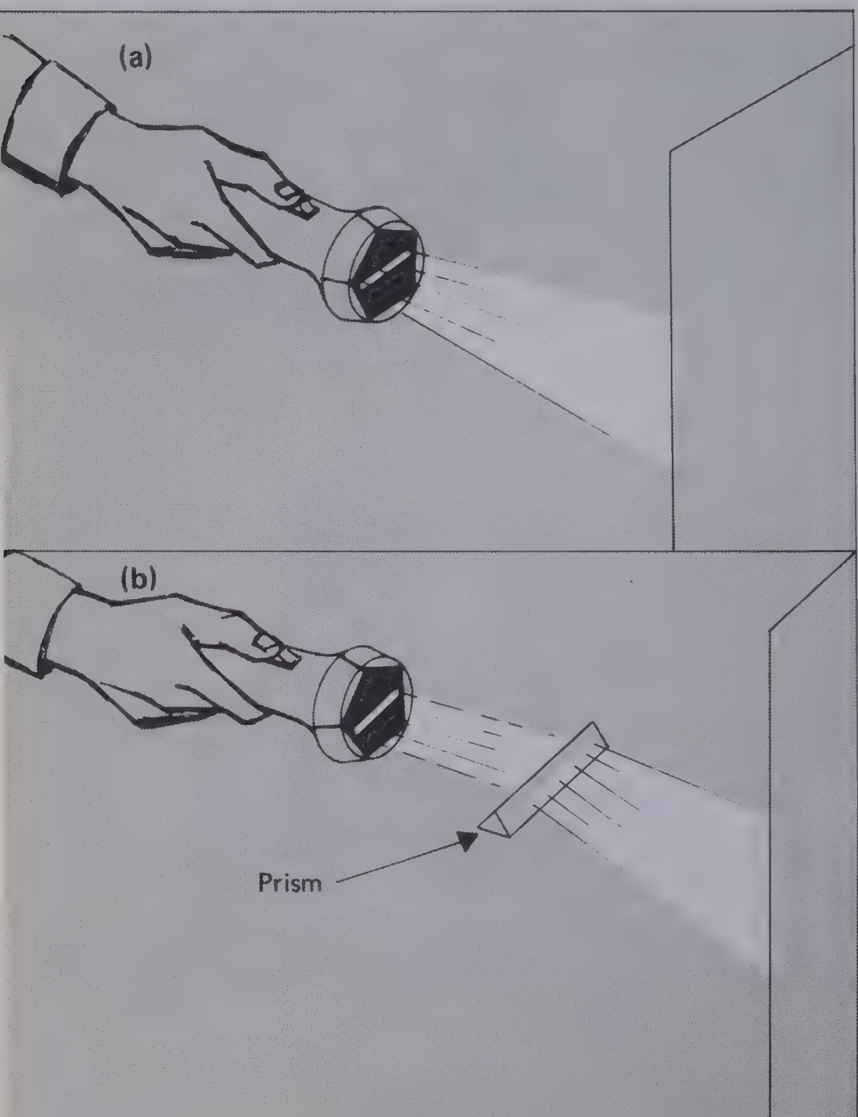


A. IT'S THE GLOW

We are always using the word *hot.* A singer or a ball player is *hot.* We read *hot* news. We strike while the iron is *hot.* But let's find out if the stars are really hot.







Being careful not to burn your fingers, hold a piece of steel wire over a burner flame.

1. What is the first color you see as it heats up?

2. What color changes do you see as you keep heating the wire?

3. What does more heat in the wire seem to do to the color?

4. Try a piece of copper wire. What do you see as it heats up?

5. Try a thin piece of carbon. What do you see?

6. Does the color depend on the material or simply on how hot it gets?

Through their telescopes astronomers can see that stars are of different colors. There are red stars, blue stars, and yellow stars.

7. What kind of star would you expect to be hottest: a yellow, blue, or red one?

B. SCIENCE IS RAINBOWS?

More information can be squeezed out of starlight. But start with ordinary light.

Cover the front of a flashlight with black paper held on with masking tape. Leave an open slit in the center of the lens about 3 or 4 millimeters wide. Shine the light on a piece of white paper.

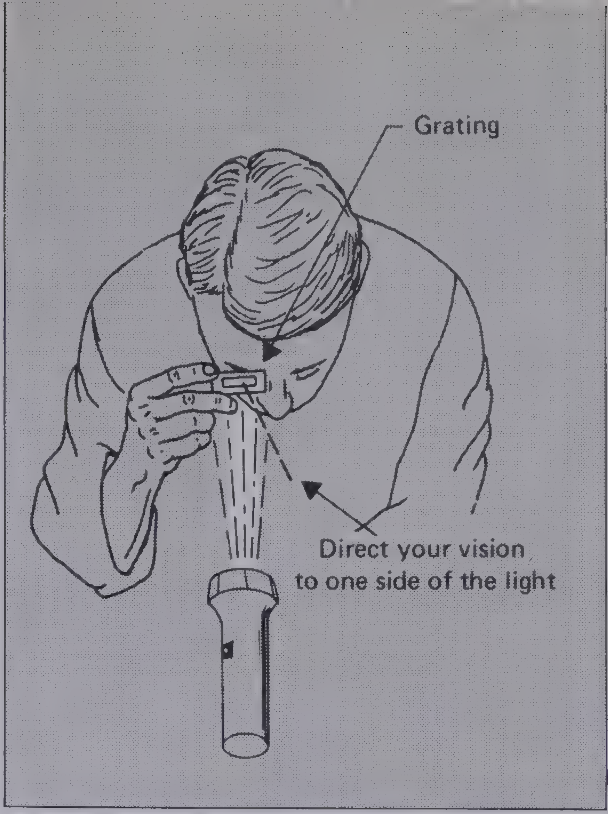
8. What color is the light on the paper?

Now shine the light on the paper through the special piece of glass called a *prism.* Lay the prism on the table. Turn the prism so you can look through the clear, slanted sides at the paper. Keep the slit on the flashlight parallel to the table. Let the light from the prism fall on the paper.

9. Describe what you see on the paper.

10. What does white light seem to be made of?

There are other ways of studying light. One device is called a *diffraction grating.* The grooves in it are so small that it would take a microscope to see them.



Look through your grating. Let the beam from the slit in the flashlight shine in the other end, slightly at an angle to the slit in the tube you are holding. Move and rotate the tube gently until you get the best effect.

11. Describe what you see.

So far you have been looking at solid things giving off light. Stars are made of glowing gases. You often look at glowing gases in the street at night. You call them neon signs.

A glass tube full of gas will be mounted at the front of the room. The room will be darkened and the power to the tube turned on. Look through your grating. Remember to look to one side of the light.

12. Describe what you see.

13. What kind of gas was in that tube?

Tubes of different gases will be connected and turned on. Observe their light through your grating.

Joan Sydlow from Nancy Palmer

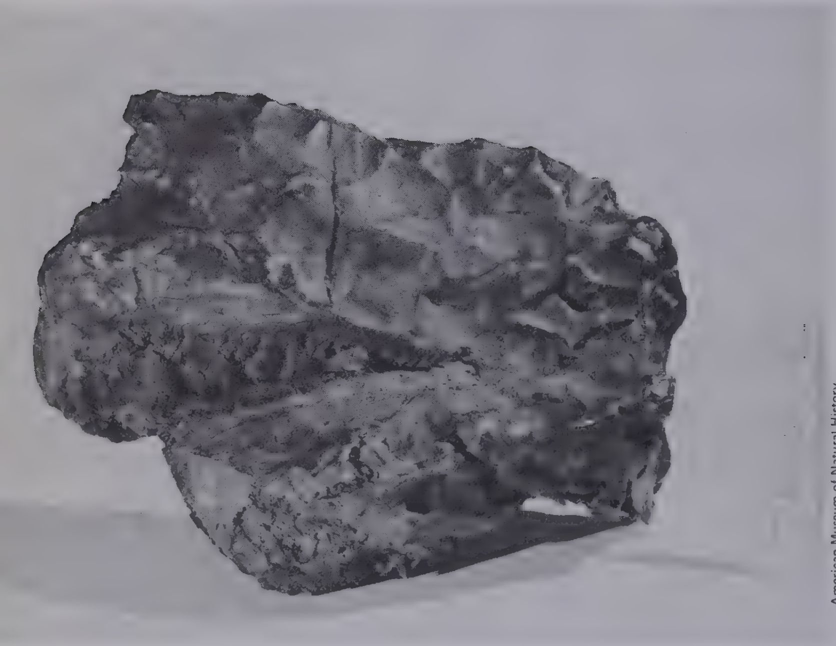
14. Write down the name of each gas and describe the light patterns it makes.

15. Are the light patterns of the gases all alike, or different?

16. If a big blob of one of these gases was glowing out in space, how could you identify it?

The spread of color seen with the prism and grating is called a *spectrum.*

17. How was the spectrum of the flashlight different from those of the gas tubes?



American Museum of Natural History

A Meteorite

C. EVERYWHERE THE SAME THING

Astronomers find that the starlight they analyze from all over the universe shows the same sets of lines we find on Earth.

Glowing chunks of matter from space are flying through our skies all the time. Up in the atmosphere—glowing—they are called *meteors.* Any one that reaches the Earth without being entirely burned up is a *meteorite.*

18. Would you expect the light patterns of matter from a meteor to be the same as, or different from, those of Earth matter?

19. Where in the universe do you think there might be entirely different matter from that on Earth?

Astronomers know the temperatures of stars and elements that make up the stars.

20. How did energy enable them to get this information?

CONCEPT SUMMARY.

Investigation 12

Turn Right for Sunshine

By now you know a lot about the ball of mud and rocks you live on.

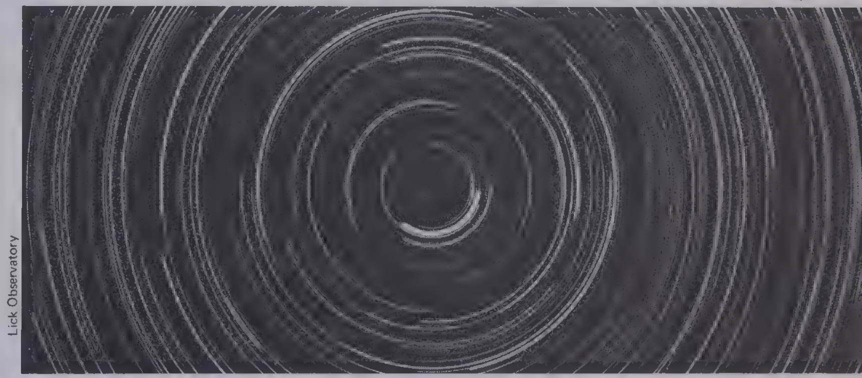
You have learned how energy runs the weather machine.

Most of the energy we have been talking about comes to the Earth from the sun. It doesn't come in a steady flow. You found that when the hours of sunlight per day were compared from month to month, there was a pattern. You also found that the amount of heat the Earth receives depends upon the angle of the sun's rays and the length of time the sun shines.

Now for the big question: what controls the amount and direction of sunshine?

A. TILT!

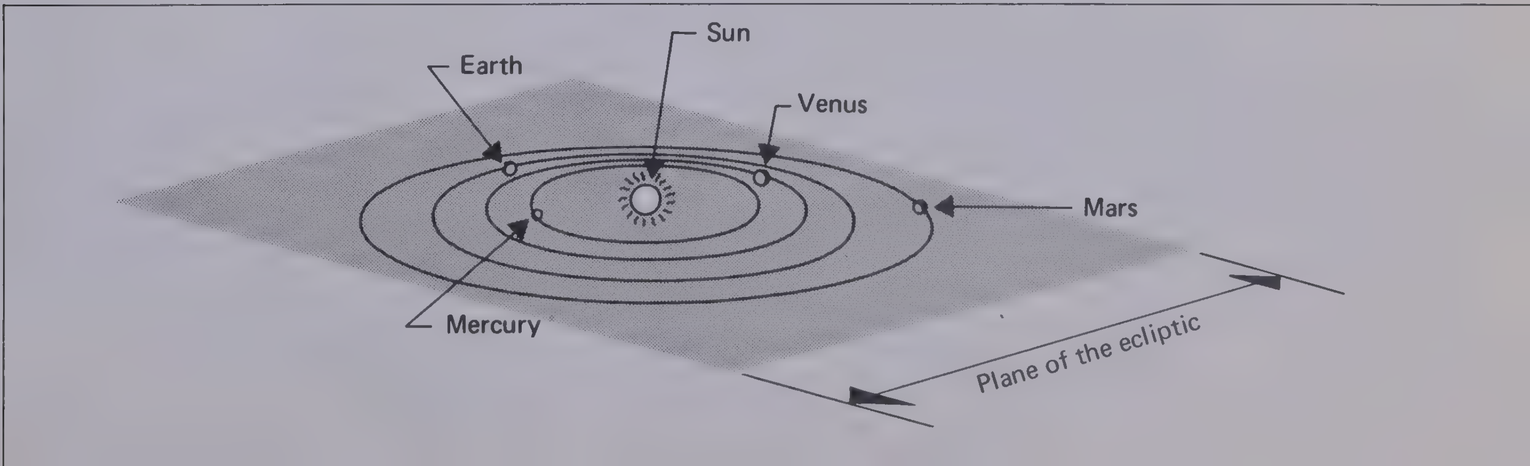
Look at the time exposure of the stars.

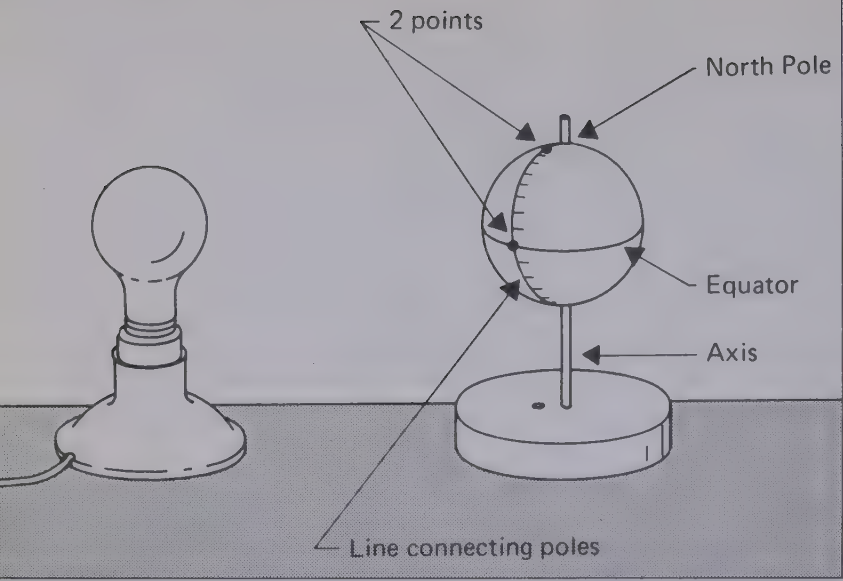


Time Exposure of Stars at Night

1. How do you explain it?

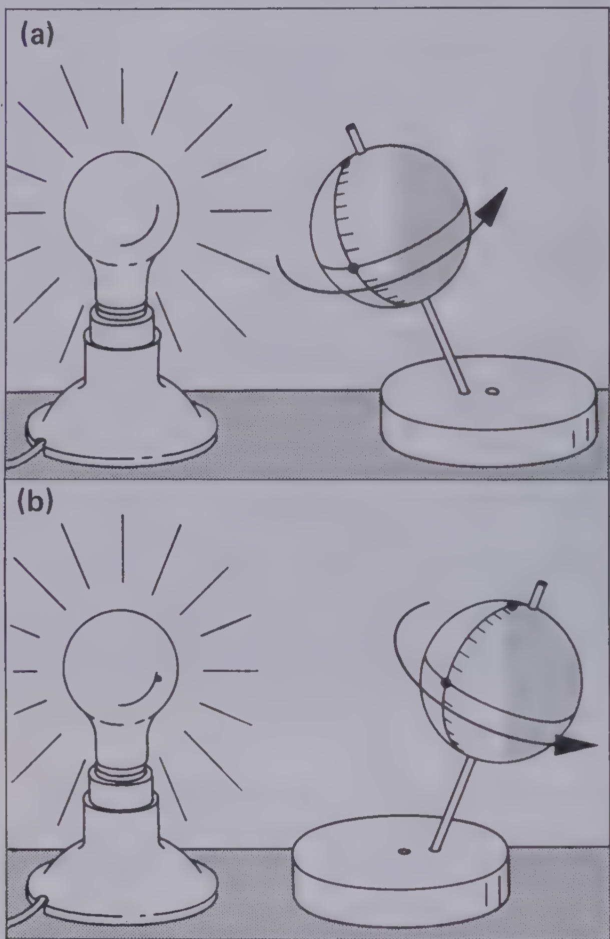
But there's more. The Earth is not only spinning like a top; it also makes a yearly trip around the sun. Imagine that its path about the sun leaves a trail. And imagine that all the other planets also leave trails. It turns out that all the trails around the sun are about level with each other, as though they were all on one flat surface, called the *plane of the ecliptic.* (The diagram of this shows only the four planets nearest the sun.) Compared to this plane, the Earth's axis is tilted. Not only that, the Earth's axis always points in the same direction (toward the Pole Star), no matter where the Earth is in its orbit.





Use a ball mounted on a base. The rod it turns on is the axis. A circle around its middle is the Equator. The place where the rod comes through the top of the ball is the North Pole.

Set the ball on your table level with a light source about two feet away. Have the axis straight up and down. Imagine a line that connects the poles. Note the point where the line crosses the Equator. Pick another point on this line very near the North Pole. Now give the ball one complete turn and observe how the light hits the two points you have spotted.



2. How long did one point stay in the light, compared to the other?

Now set the axis in the base so that it is tilted toward the light source. Give the ball a turn and watch the light on the two points.

3. Which point stayed in the light longer?

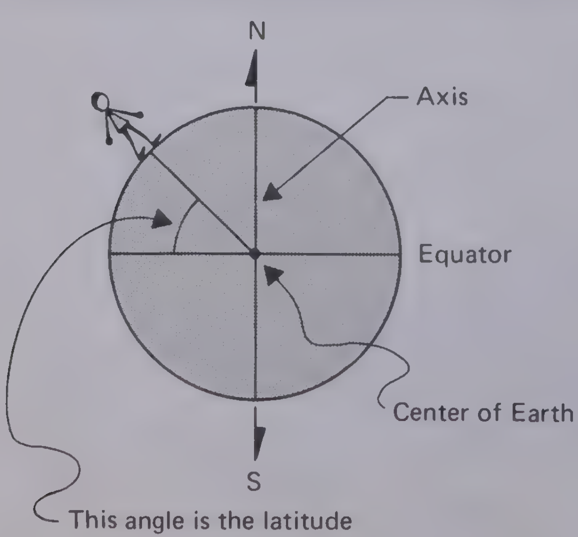
Set up the ball so that the axis is tilted away from the light and turn it again.

4. Which point stayed in the light longer?

5. What would happen to the length of the day, in one part of the world compared to another, if the Earth's axis became straight up and down?

B. WHEN THE DAYS DWINDLE DOWN

You see how tipping the Earth's axis toward or away from the sun affects the amount of daylight. But can the amount of daylight change throughout the year if the Earth's axis always points in the same direction? Maybe being farther north or south has something to do with it. This is called *latitude.* It is the position determined by the angle between imaginary lines drawn through the center of the Earth, the Equator, and *you.* The angle is your latitude.



Find the latitude to the nearest whole degree of your city. If no one knows it, Table No. 1 will help you come close. Find the place nearest you for your approximate latitude.

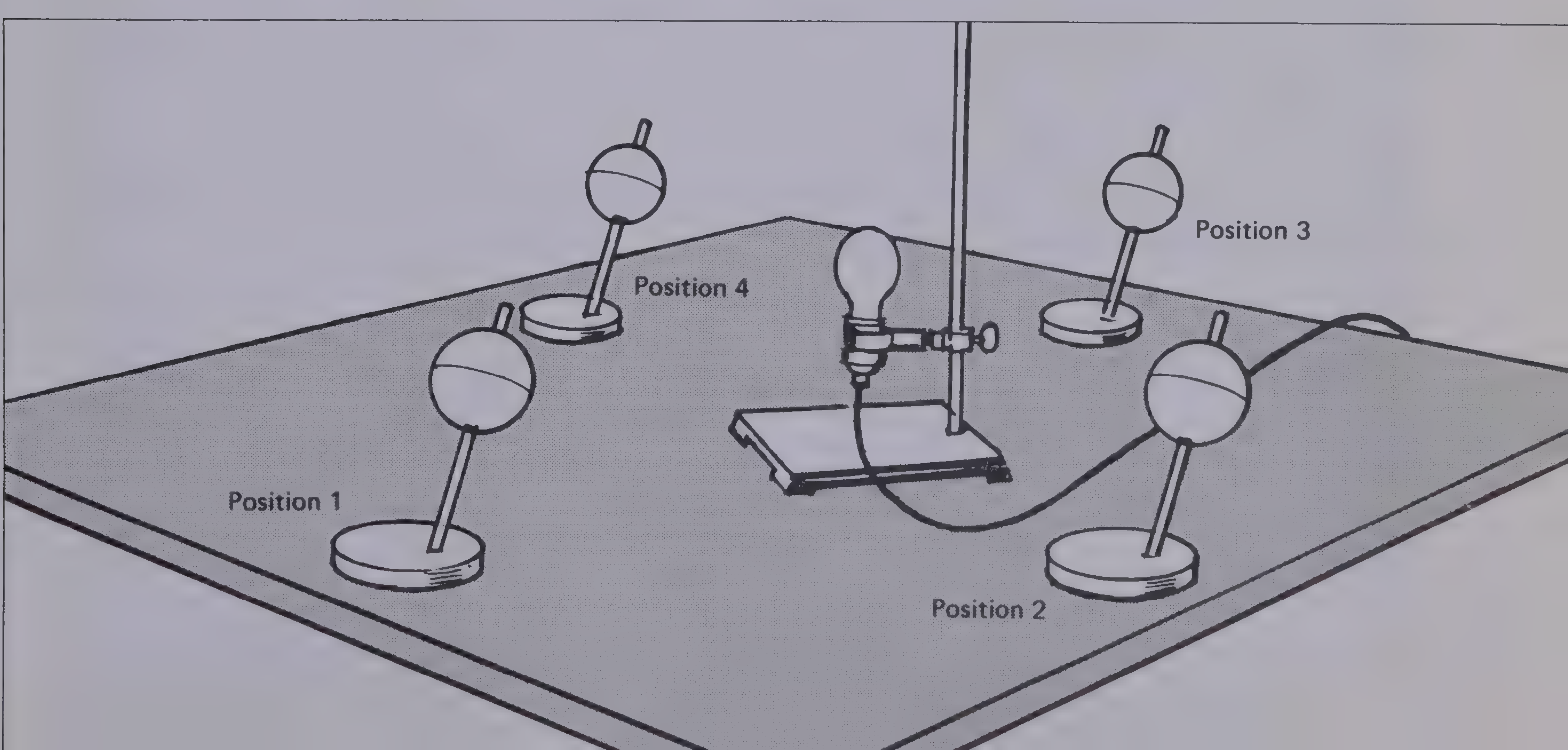
TABLE NO. 1

APPROXIMATE LATITUDES OF SELECTED PLACES IN THE UNITED STATES

about 48°N	Seattle (Wash.); Great Falls (Mont.); Grand Forks (N.D.)
about 45°N	Traverse City (Mich.); Bangor (Maine)
about 44°N	Boise (Idaho); Rapid City (S.D.); Fond-du-Lac (Wis.); Watertown (N.Y.)
about 40°N	Reno (Nev.); Price (Utah); St. Joseph (Mo); Dayton (Ohio); Wilmington (Del.)
about 36°N	Dalhart (Tex.); Dyersburg (Tenn.); Elizabeth City (N.C.)
about 33°N	San Diego (Cal.)
about 31°N	Douglas (Ariz.)
about 30°N	Houston (Tex.); Panama City (Fla.)
about 28°N	Corpus Christi (Tex.); Tampa (Fla.)
about 26°N	Brownsville (Tex.); Miami (Fla.)

6. What is your approximate latitude?

Using a protractor, find your latitude on the ball as a spot on the line from the North Pole to the Equator. Mark it with chalk or light pencil. Mount the ball in a tilted position. Set it about two feet from the light, with the axis tilting toward the light.



Turn the ball all the way around on its axis. Note how long your marked spot stays in the light. Decide if it is "half a day," "more than half a day," or "less than half a day." Record it this way in Table No. 2 on the data sheet under Position 1.

Move the ball ¼ of the way around the light, keeping the axis pointing in the same direction. Now the axis should no longer be pointing toward the light. Again turn the ball around on the axis. Note how long your latitude point stays in the light. Record this under Position 2.

Move the ball another ¼ of the way around the light. Now the axis should be pointing directly *away* from the light. Measure and record under Position 3.

Move the ball another ¼ of the way around the light. Keep the axis direction the same as in the three previous positions. Measure and record under Position 4 in Table No. 2.

7. What happened to the length of the day as you traveled around the sun?

Decide which positions represent each of the four seasons. Write your answers in the table.

8. How much time would it take for the Earth to go from Position 1 all the way around and back to Position 1.

9. Look at the ball and light again. Which of the positions would have the light most nearly overhead?

10. What season would this be?

11. If you gave the ball one turn during this season, how much time would the North Pole be in the light?

12. In what position is the light least nearly overhead?

13. What season is that?

14. During this season, how much time does the North Pole spend in the light?

You have spent a quick year out in space. You have recorded changes in the amount of sunlight your part of the Earth receives. You know what decides how much heat energy reaches the Earth.

15. What does the Earth do that makes fewer hours of sunlight in December than in July?

16. What does the Earth do that changes the angle of the sun?

17. What does the Earth do that changes the seasons?

CONCEPT SUMMARY.

Idea 5
Technology

Investigation 1

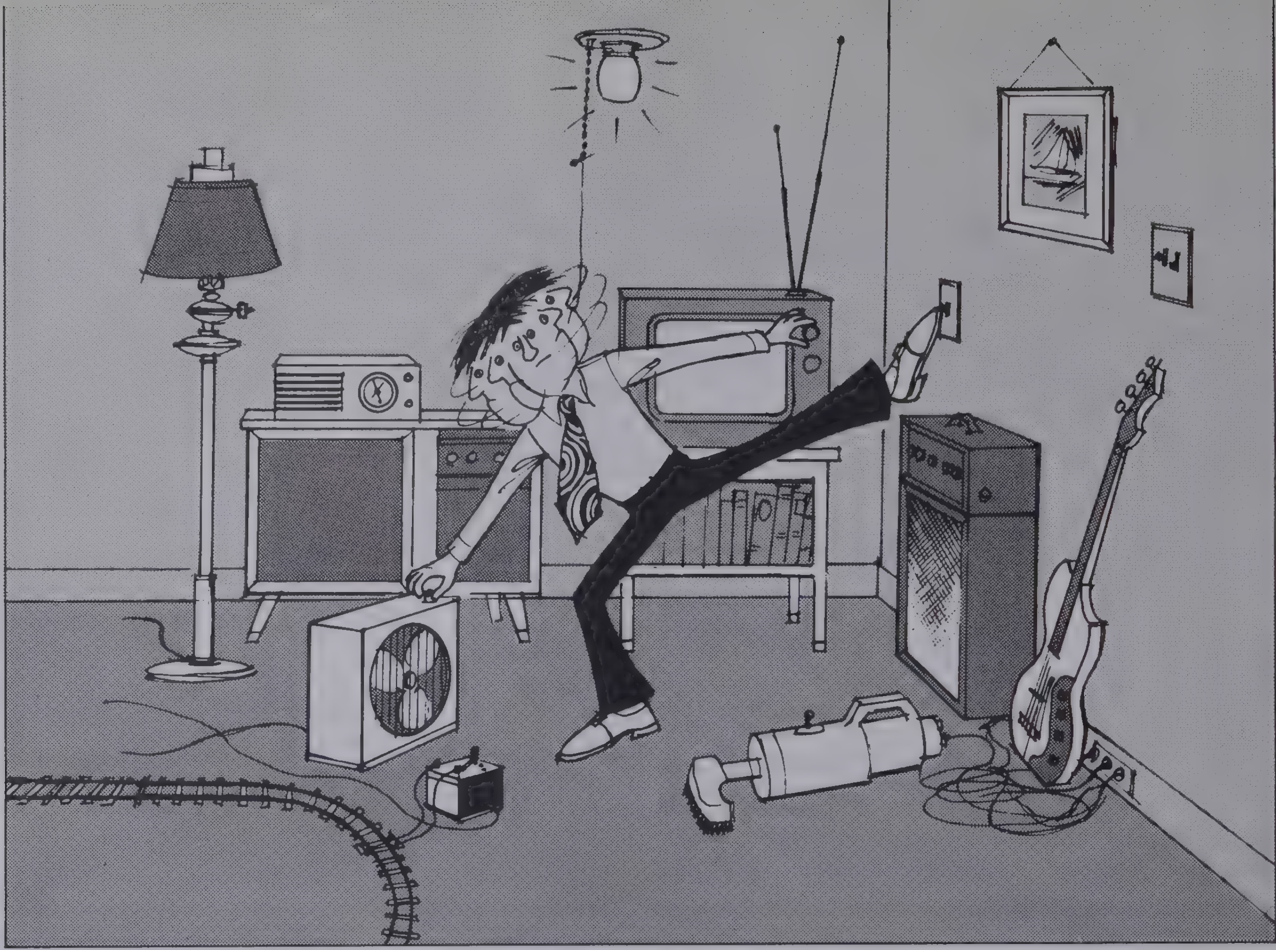
You Turn Me On

The disk jockey on the clock radio tells you when it's time to roll out.

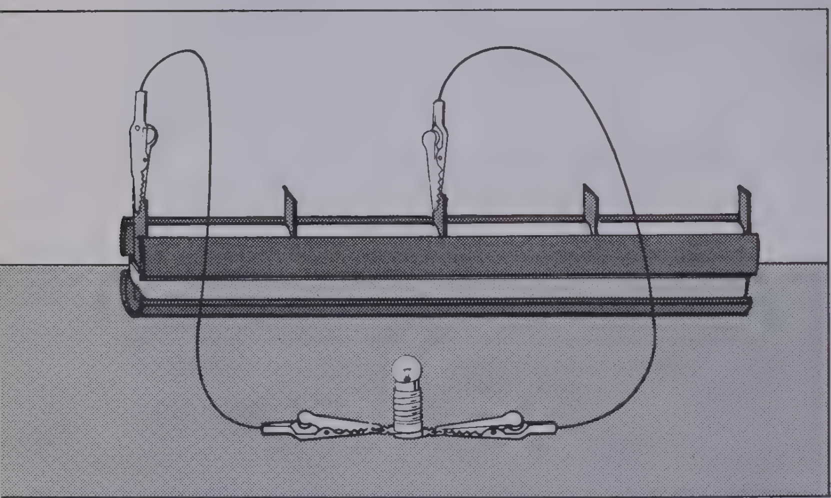
The weather outside is miserable, but in the house you're still warm as you throw back the covers. If it's still dark outside you turn on the lights. There is hot water in the bathroom. When you get to the kitchen you turn on a radio there. A flip of the switch puts the toaster to work.

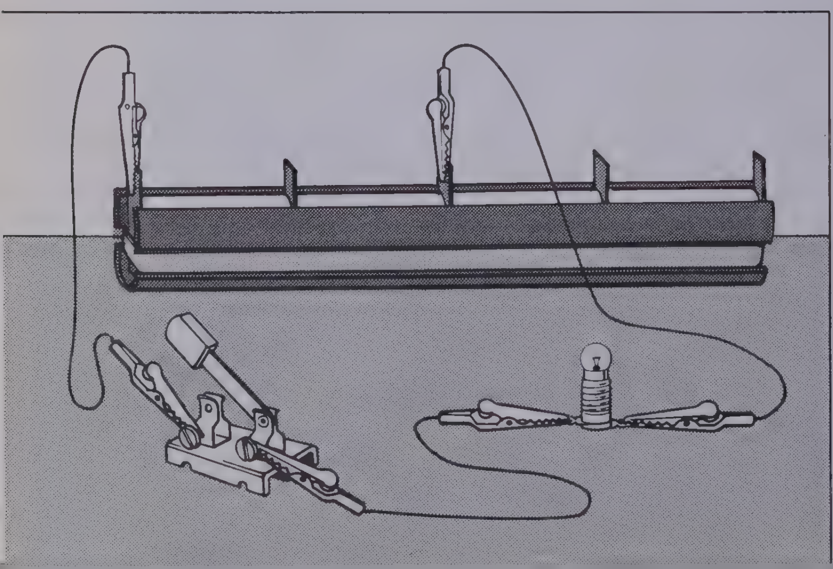
The phone rings. Your friend wants to know what the English assignment is.

Sybil Shackman from Monkmeyer Press Photo Service



It's the start of a typical day. Look what you've done so far. You turned on the lights, the radio, and the toaster. You used the telephone. You seem to do a lot of turning things on and off these days. You have to be an expert in switches.





A. PUSH THE BUTTON

Switches aren't found only at home. There are switches on the little transistor radio you listen to between classes. The car has an ignition switch. The horn works on a switch. A switch on the brakes turns the taillights on.

All switches turn things on and off. Let's find out something more about them.

Use the alligator clips and leads to hook up a flashlight bulb to two batteries in your battery pack. The light goes on.

1. What must you do to turn the light off?

Use another lead with clips to connect a switch to the circuit.

2. What does the switch let you do?

3. Are switches really necessary? Why not just twist wires together to turn the lights on at home?

So far you have been the one who decides when a switch should go on or off, and you have been the one who flips it. But there are switches that seem to decide for themselves when they should go on and off, and they flip themselves.

B. BLOW HOT AND COLD

For instance, the hot water heater turns itself on and off. A little box on the wall can take care of the heat in the house, once you tell it what temperature you want. A switch makes the toast pop up automatically when it's done. Set an electric iron for wool, cotton, or silk, and it takes care of the rest. The oven will stay on 350° for a roast for hours. The kind of switch that does all these things for you automatically is worth knowing better. How does it work?

Christa Armstrong from Rapho-Guillumette

The special switch will be used in a circuit like you used in part A: a flashlight bulb and the special switch will be connected to two batteries in your battery pack. The screw on the special switch will be adjusted so that the light *almost* goes out. Then the screw will be warmed by breathing on it.

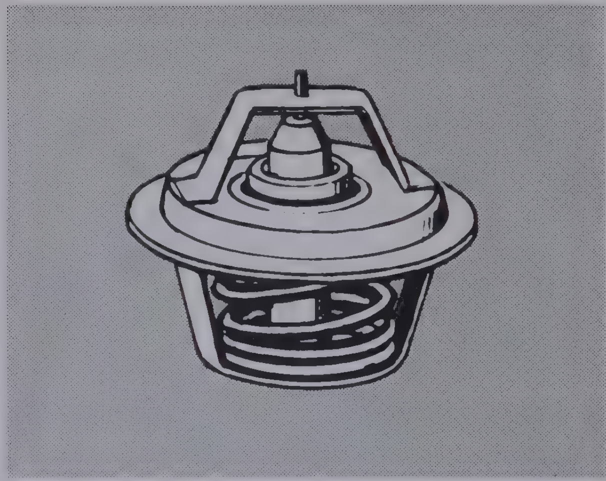
4. When the screw was breathed on, what happened?

5. When the screw was cooled by being blown on, what happened?

6. What interacts with this type of switch to make it work?

7. What is this kind of switch called?

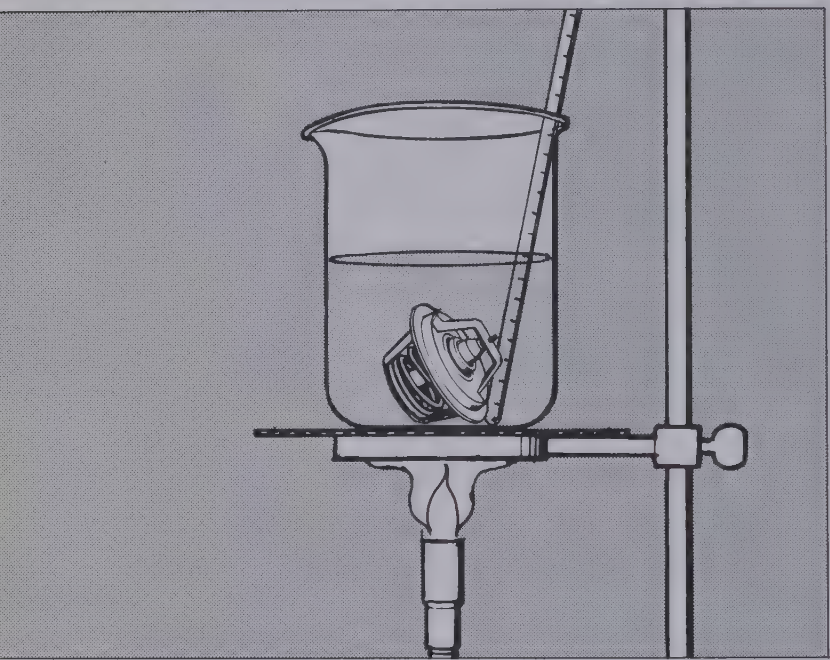
C. DON'T STOP CIRCULATING



All switches don't work on electricity, nor are they all for letting electric current flow. Here's one that's different. It controls the flow of water between the pump and the radiator in your automobile. Take a good look at it. Find where you can make it open by pressing hard against the spring.

8. What has to happen to let water flow through it?

The switch will be placed in a 600 ml beaker with enough water to cover it. A thermometer will be put into the water, and a burner used to heat the water. Watch closely when the temperature gets to around 70°C.



9. What happens to the switch?

10. At what temperature does it happen?

11. Why is there a switch like this in an automobile cooling system?

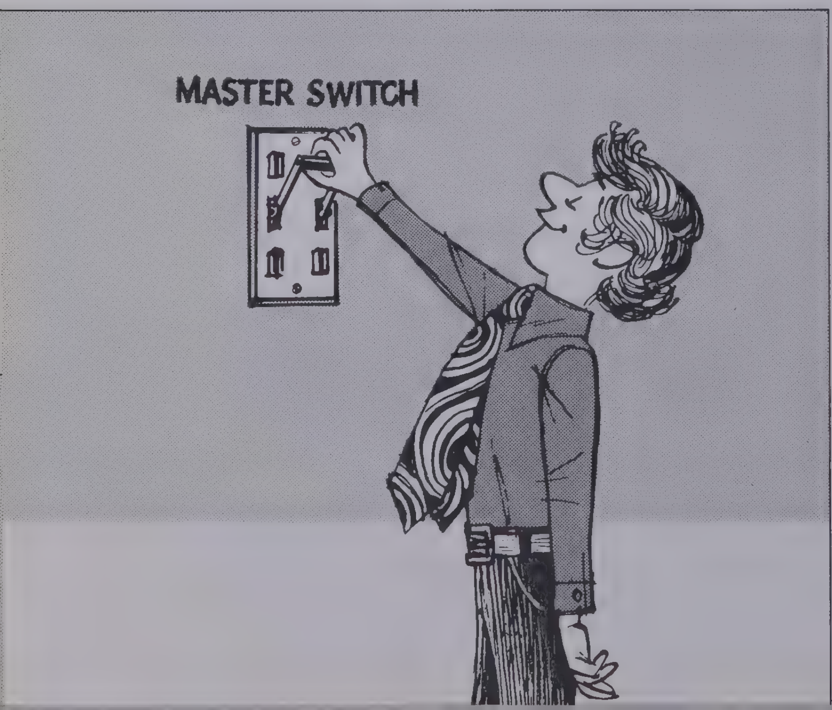
12. What is interacting with this switch to make it work?

If switches let you decide when things run, or how hot or cold something should be, then they put you in charge of what goes on around you. Another word for being in charge is *control.*

13. What do switches control?

14. How do switches work that you don't flip yourself?

CONCEPT SUMMARY.



Investigation 2

Block that Breeze

In the house, it is warm and comfortable. Outside, the mercury is at the bottom of the thermometer. If you have to go out, you need lots of extra layers of clothes.

We put on and take off clothes so often, as the temperature changes, that we don't even think about it. Staying warm or getting cold is a matter of keeping or losing energy. You have controlled energy with switches, but a heavy coat to control energy seems like a different proposition. What kind of action does it have?

A. FROSTY FINGERS

We wrap things to keep heat in. We also wrap them to keep heat out, like the special bag to take the ice cream home from the store.

Try it with straight ice. Take two ice cubes. Wipe them off with a paper towel and weigh them separately. Write the weights in Table No. 1.

Quickly wrap one cube inside two paper towels. Place the other cube on a paper towel, unwrapped. After 10 minutes, unwrap the ice cube in the towels and weigh it. Wipe the water off the unwrapped cube and weigh it. Record the weights.

For each cube, subtract the second weight from the starting weight, and record as "Weight Lost." Find the percent of weight loss for each cube. First divide the weight lost by the starting weight. Then multiply the answer by a hundred. Record your results.

1. Which cube had the bigger percent of weight loss?

2. What does it take to make ice melt?

3. What did wrapping the ice cube in paper towels do?

4. What does an ice cream bag do?

B. INTO THE FLAMES

Paper is only one kind of matter. Let's see whether other kinds of matter will interact with heat in the same way.

Take a copper rod. Hold one end in a flame.

5. What do your fingers tell you pretty soon?

Take a glass rod and do the same experiment.

6. What do your fingers report?

Try the same thing with an iron rod.

7. Which does it act like, the glass or the copper?

Do it once more, this time with a carbon rod.

8. Which of the others does it act like?

9. Make a list of the four materials with the best heat carrier first and the poorest heat carrier last.

10. Why is copper used in automobile radiators?

11. Why is fiber glass used in the walls of ovens?

12. Carbon tools are sometimes used to shape hot glass. Why not use copper or iron?

Corning Glass Works

13. Which material would you use to make a pot, if you wanted the water in the pot to boil in a hurry? Why?

Plough, Inc.

C. SPACE IS CROWDED

So some substances carry heat better than others. If a substance carries heat well, it is called a *conductor.* Silver is the best solid conductor.

14. What would a thing be called that doesn't conduct heat well?

Heat gets around in other ways. There is not enough matter in the space between the sun and the Earth to be a real conductor, but the heat seems to get here just the same.

Turn on a lamp. Hold your hand about a foot away.

15. What do you feel?

Put a piece of cardboard between the lamp and your hand.

16. Now what do you feel?

Christa Armstrong from Rapho-Guillumette

Energy moving through space is called *radiation.* Radiation, like X-rays and gamma rays, is harmful. But not all radiation is harmful. Light, heat, and radio waves all radiate through space.

17. What do dark glasses do about the sun's radiation?

D. LIGHT THE LAMP

Along with heat and light, one of our most important forms of energy is the one you use from the click-on of the radio in the morning to the click-off of the TV at night. How does electricity fit into what you have been testing?

Hook up the light bulb to the battery pack. Use an extra lead with clips to hook a copper rod into your circuit.

18. What happens?

Test the iron, carbon, and glass rods the same way. Move the clips around a bit to be sure you make good contact.

19. What are your results?

20. What is a rod doing when the light is on?

21. What can you say about glass?

22. Why are power lines often hung on glass supports?

23. What material is used for wiring a house?

24. What does the coating on the wires do?

25. Compare how well copper and glass carry heat and electricity.

26. What does this information suggest?

Someone has to decide what material to use for each job to be done. Soft plastic may be all right for a juice pitcher, but hard steel makes a better knife blade. You wouldn't make a hammer out of glass or window panes of copper. Whatever is used must do a certain job. Many of these jobs have things in common.

27. When you place a hot frying pan on an asbestos pad, what does the pad do to energy?

28. What does a heavy coat do to the energy of your body?

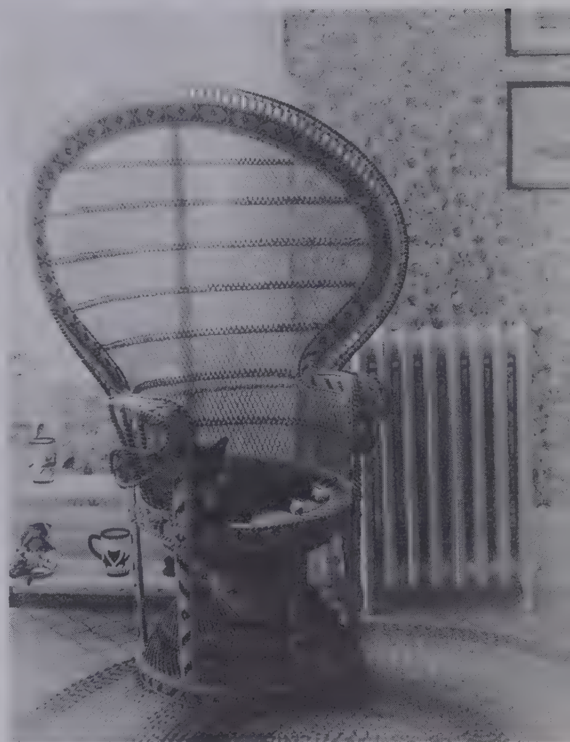
CONCEPT SUMMARY.

Investigation 3

I Made It Myself

We control energy in many ways. Sometimes we want to keep it in and other times we want to keep it out. We use wires, windows, fans, clothing, fiber glass, rock wool, blankets, radiators, asbestos shingles, and a million other things, all to make energy either move or stay put.

Johns-Manville



A. IT'S UNDERFOOT

What are all the things that we use made of?

Look around your classroom. Think about the things you see: the ceiling, the walls, the floors, the desks, the windows, and anything else you notice.

1. List the different materials used to make all these things.

Tom Mook from Bethel

Save-the-Redwoods League

Henry Monroe from dpi

2. How many of these materials would you expect to find in the same form in a forest?

Most Americans live in cities. They may never touch unpaved ground from one end of the year to the next. What do they touch? Investigate the stuff they walk on.

Use a disposable aluminum pie pan. Take a small container as a measure. Be sure it's dry. Put one measure of cement powder in the pan. Add 6 measures of sand mixed with fine gravel. Use a stick to mix it all together thoroughly. Bunch the mixture into a pile and hollow it out in the middle.

Half fill your measure with water. Gradually pour water into the middle of the sand and cement mixture. Use the stick to mix everything together and make it into a mortar. Go slowly with the water; don't add more than you have to. Make the mortar mushy but not too watery.

Scrape your mortar into a paper cup. Mark it with your name and let it set overnight. Next day tear away the paper cup and see what you have.

3. How much is it like the original sand, gravel, and powder?

Use a nail or paper clip to test the hardness of the mortar. If necessary, let it dry another day.

4. When it is good and dry, describe its properties.

5. How could you get back the original sand and gravel?

6. Is mortar natural or man-made?

7. Are the sidewalks we walk on natural or man-made?

B. STUCK UP

Man-made things come from many different natural materials. The cement powder you used was made from limestone and certain kinds of clay. Here is a substance found in living things. It is called *urea.* What you have here are pure urea crystals. Stir 3 g of urea into 20 ml of water in a beaker.

8. What happens? Describe what you have.

Rinse out the beaker. Weigh out 4 g of urea crystals and put them in the beaker. Add 25 ml of formaldehyde and 5 ml of dilute hydrochloric acid. Stir the mixture and let it stand for a few minutes.

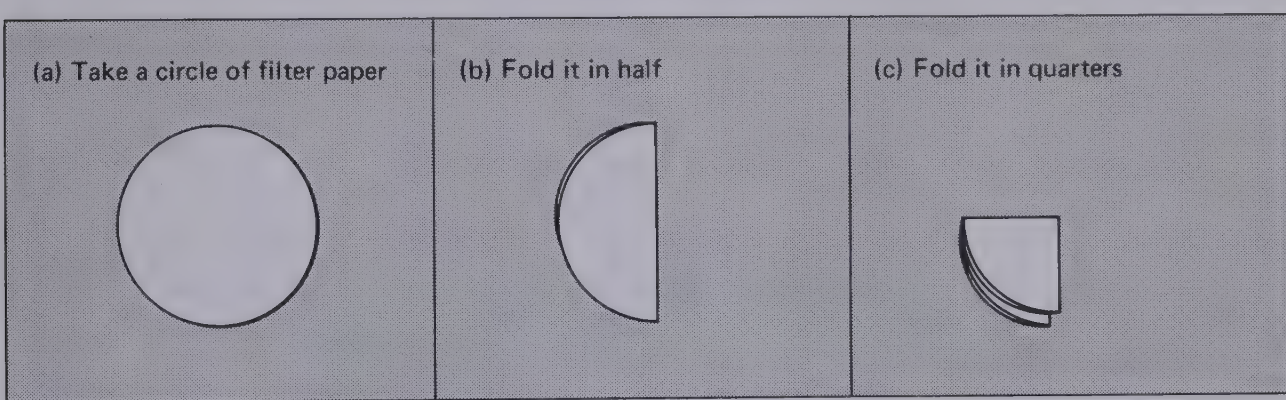
WARNING: THESE CHEMICALS ARE POISON. HANDLE THEM WITH CARE. WASH YOUR HANDS WHEN YOU ARE FINISHED.

9. What happens to the mixture in a few minutes?

10. Hold the beaker in your hand. What do you feel?

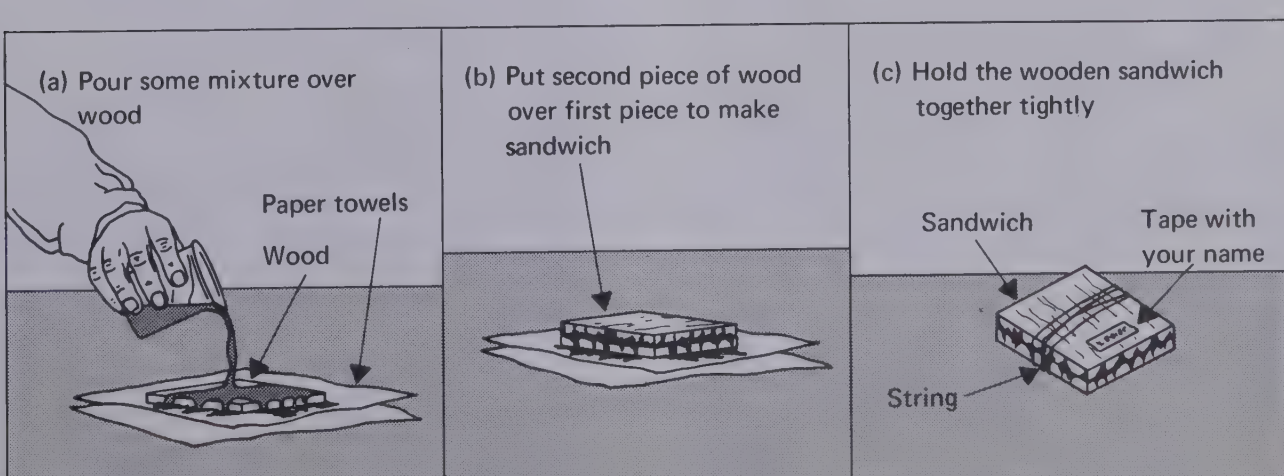
11. What is happening in that beaker?

Fold a filter paper as shown below, and fit it into a funnel. Put the funnel into a clean, dry beaker. Slowly pour into the filter paper about a teaspoonful of your urea mixture. When the funnel has stopped dripping, carefully spread the filter paper out on a paper towel.



12. Examine the stuff you have and describe its properties.

Put 2 small, flat pieces of wood on paper towels. Pour some of your mixture in the beaker over one side of a piece of wood. Spread it around so that it soaks in well. Do the same with the other piece of wood. Then put their wet sides together, like a sandwich. Tie string around them or pile books on top of them to hold them together tightly. Put your mixture from the filter paper in the cracks between the 2 pieces of wood. Write your name on them and let them sit overnight. Wipe up any spilled chemicals.



Take off the string or books. Try to separate the 2 pieces of wood.

13. What happens?

14. How do you think plywood is made?

C. IT'S NOT FOR REAL

Whether it's paint or raincoats, crash helmets or fingernail polish, you are surrounded by man-made materials. You live in a man-made house. Your clothes weren't just skinned off a dead deer or bear. You come to school by walking on sidewalks, not by swinging into school on a vine.

Courtesy Associated American Artists

United Press International Photo

15. How much of the landscape on the way to school is in its natural state?

16. How much of your daily surroundings is natural and how much is man-made?

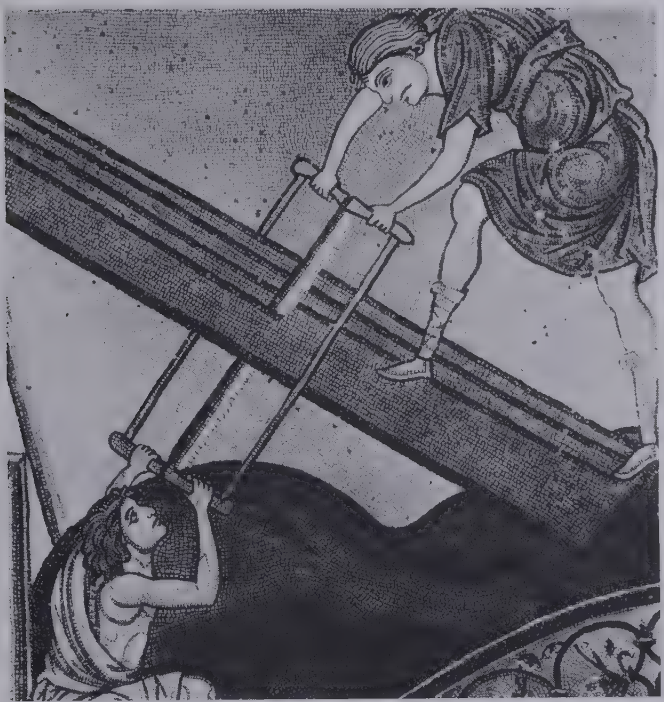
17. Is everything about your man-made environment good? Explain.

CONCEPT SUMMARY.

Investigation 4

The Force to Move Mountains

Man has been changing matter from one form to another since ancient times. Some of the more recent results of these changes are nylons, gasoline, and plastics.



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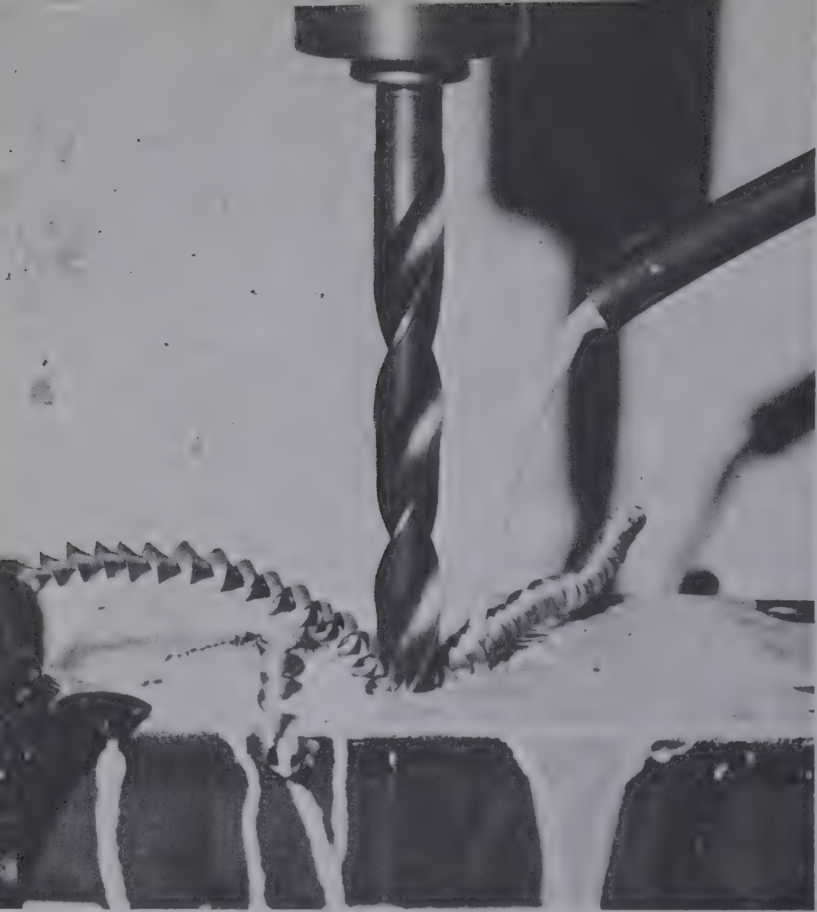
It isn't only matter that changes its form. Energy does too. Things in our man-made world come from changing forms of matter, but what makes everything tick is energy that is changing its form.

A. TURN IT ON

Think about your daily activities. How much of your work is not straight muscle power but starts with a switch? Lights, vacuum cleaners, record players, washing machines, electric typewriters, mixers, grinders—these all start when you throw the switch. But what about the power?

A. T. & T. Co.



Chicago-Latrobe

1. If you push a button and a machine starts working, are you supplying the energy that does the work?

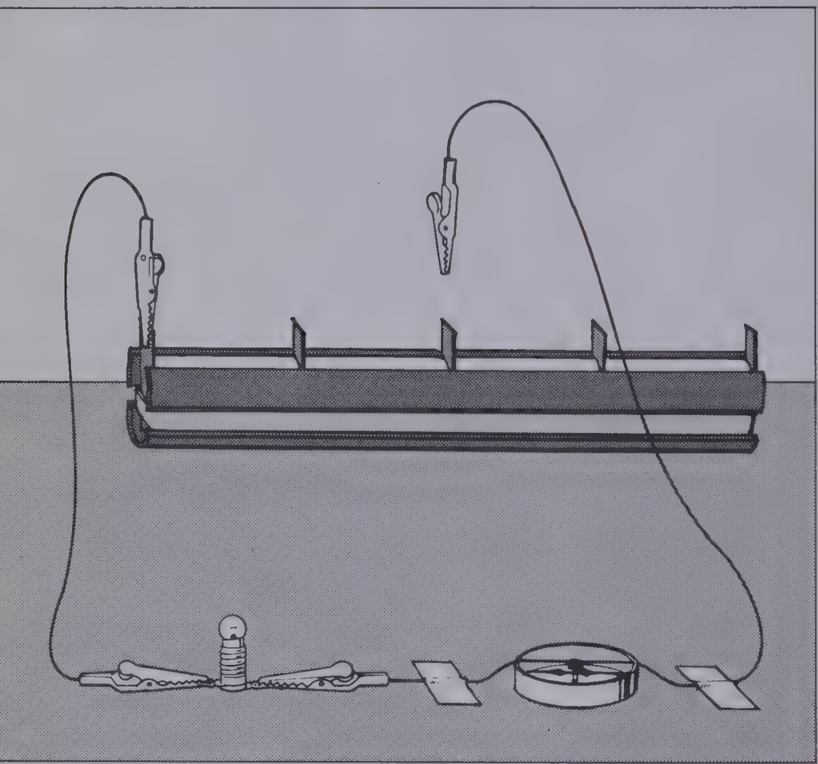
2. Of all the energy being used on jobs in the U.S., about how much do you think is muscle power: 50%, 20%, 1%?

When a drill bores a hole in metal, the end of the drill gets hot. Mechanical energy is becoming heat as it does work. Let's find out what happens to electricity. Turn on a light bulb. You can see light energy being produced. Put your hand near the bulb.

3. What other form of energy do you notice?

Electrical energy causes another change you should know about. Bring a magnet near a compass.

4. What happens to the needle of the compass?



Set up the light and battery pack. Before turning the light on, place a compass on the table. When the needle stops swinging, lay one of the wires to the light over the compass. Have it parallel to the needle, as in the picture. Use masking tape to hold it in place. Complete the circuit so the light goes on.

5. What happens to the compass needle?

6. Reverse the leads to the battery pack. What happens?

7. If you put a coil of wire around the compass instead of one wire on top of it, what do you predict would happen?

8. Try it. What happens?

9. What are you getting from electrical energy?

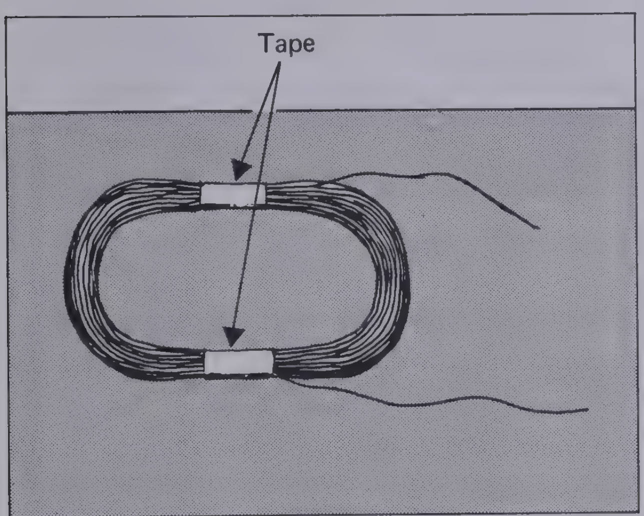
B. SALT WATER POWER

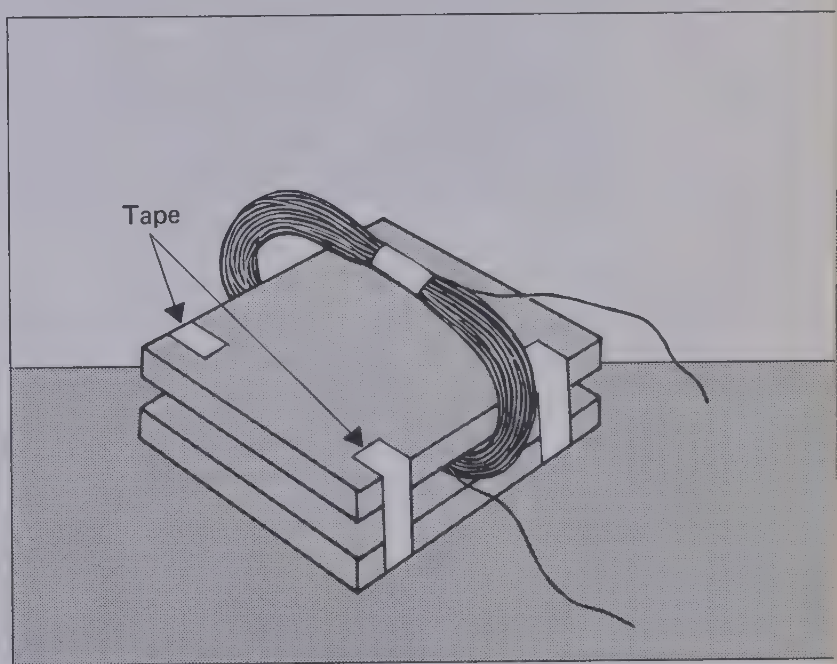
You take electrical energy for granted. Put the batteries in a flashlight and push the button. Snap–instant electricity. Transistor radios, portable tape recorders, flash attachments for cameras: all should work without a thought. What goes on in the batteries to do this?


Jack Rosen - PIX

You have a clue. In Idea 2, *Matter,* you used electricity to break water into hydrogen and oxygen. Can we get electricity by bringing two different kinds of matter together?

Let's find out. Wrap 20 feet of thin copper wire in a loop large enough for your compass and one of the pieces of wood to fit into.

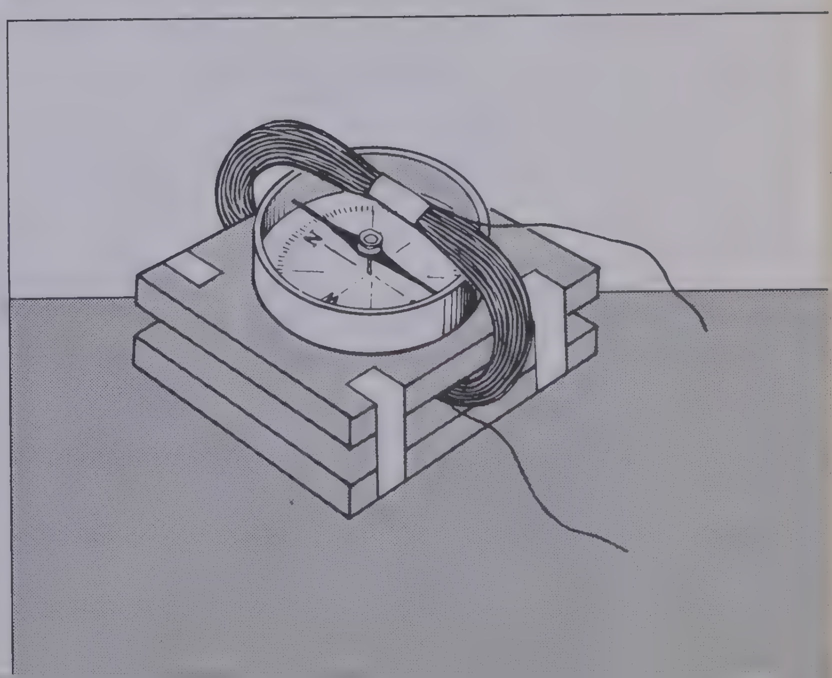




Put some tape around the top and bottom of the coil to hold it together. Make a support for your coil by taping it to the two pieces of wood. Sandpaper the ends of the wire to remove any enamel insulation.

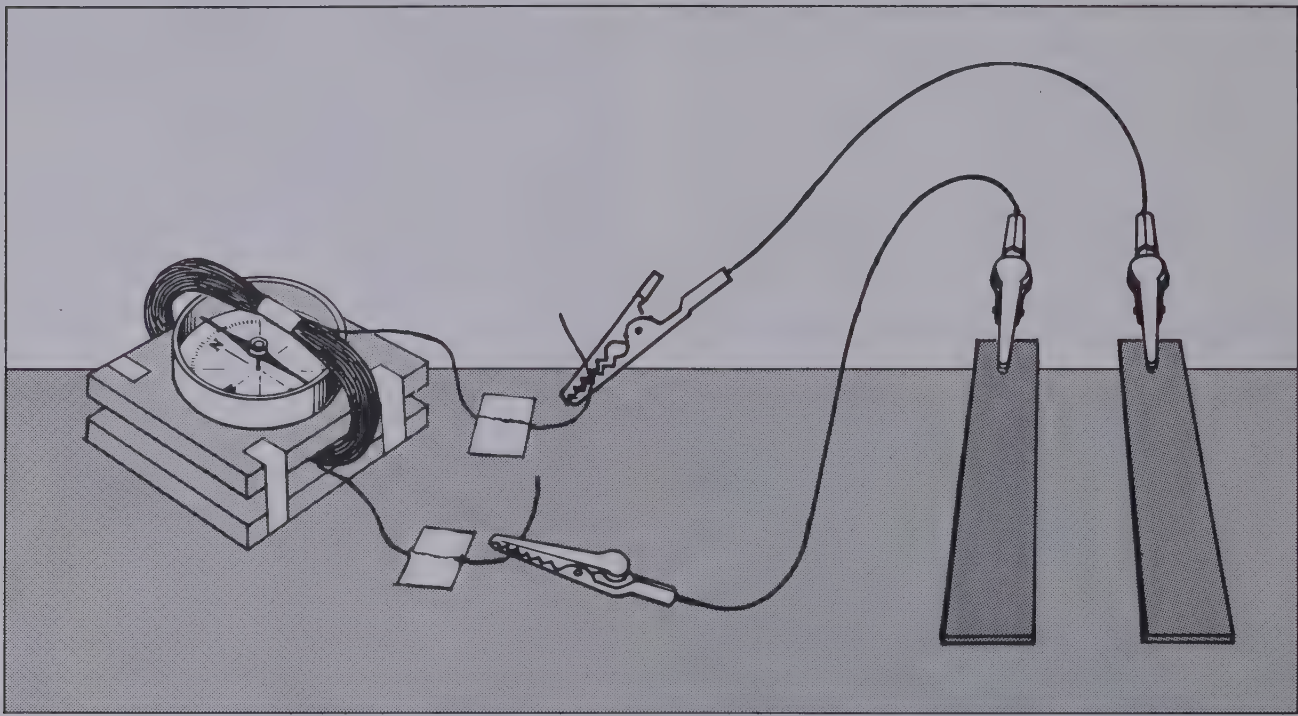
Place your compass at the center of the coil. Rotate the wooden support until the compass needle points in the same direction as the wire in the coil. Tape down the wire ends to the desk.

Make sure the compass is level.

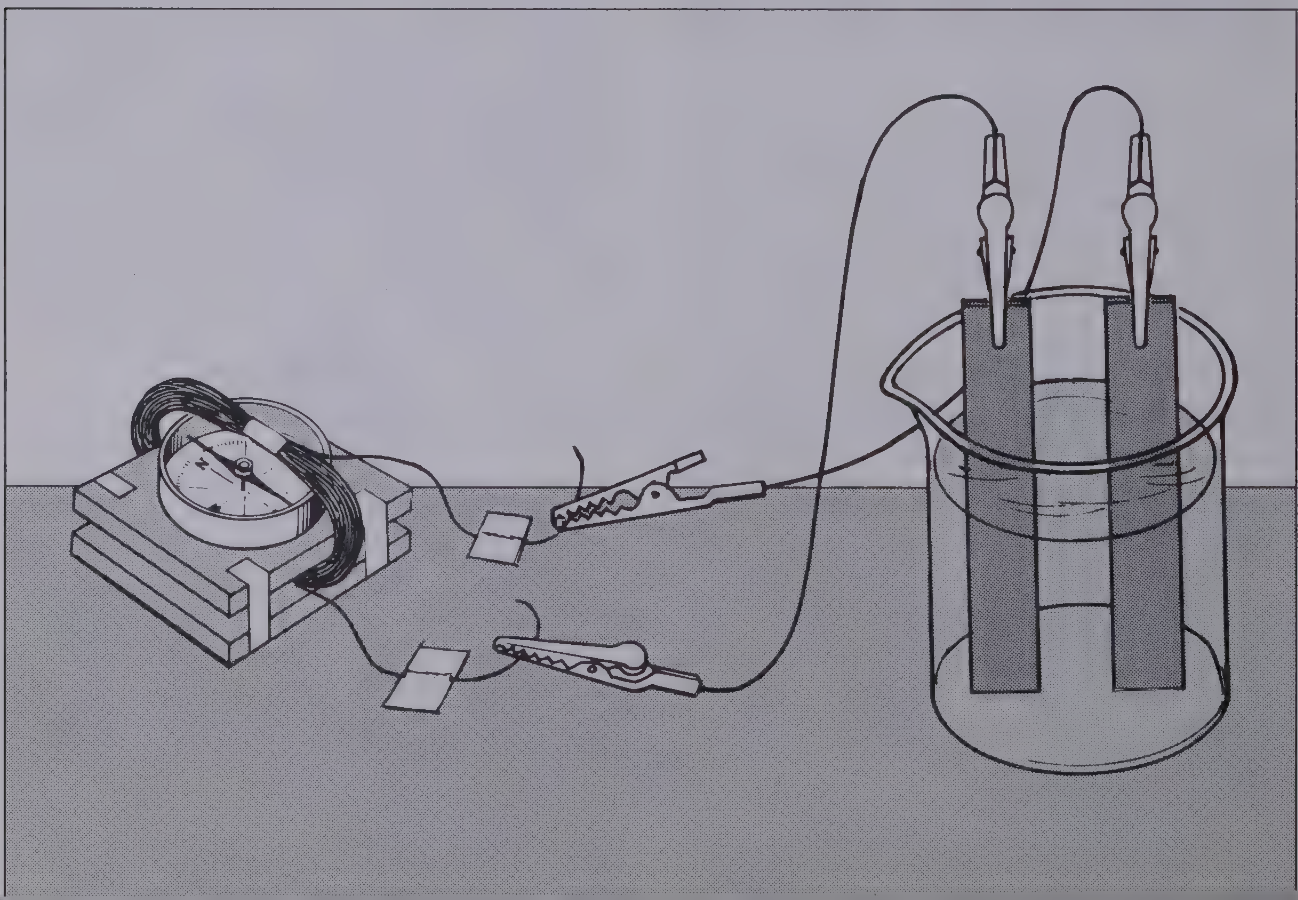


Clean a copper metal strip by sandpapering it. Attach one end of your connecting wire to the strip and the other end to one of the wires from the compass.

Repeat, using the other connecting wire and another copper strip.



Fill a beaker half full of water. Watch the compass needle as you dip the ends of the copper strips into the water. If the compass needle moved, it means that your copper strips and the water must have produced electricity that moved through the wire surrounding the compass.



10. Did the needle move?

Half fill another beaker with water. Add a teaspoon of table salt and stir. Dip the copper strips into this.

11. Did the needle move?

Remove one of the copper strips and put in its place the piece of magnesium ribbon. Dip this and the copper strip into the first beaker (the one with pure water).

12. Did the needle move?

Now dip them into the beaker to which you have added salt.

13. Did the needle move?

14. Compare any movement of the needle in pure and in salt water. Which produced more movement?

Now for a prediction. In a minute you will dip two pieces of magnesium ribbon into the salt water.

15. Do you think the needle will move when you do this? Explain.

Go ahead and try it to test your prediction.

Your teacher may have on hand some other metals. Try all the metals you have, to see which combination of metals makes the needle move the most when put into salt water.

16. Which combination makes the needle move the most?

17. Perhaps you can now answer a question already asked: Can we get electricity by bringing different kinds of matter together?

C. ENERGY MUST ACT

When one substance reacts with another substance, what happens is called a *chemical change.*

You just connected wires to reacting substances.

18. What kind of energy did the reacting substances produce?

19. What does the battery do in a flashlight, a transistor radio, and an automobile?

You use the same kind of energy at home when you plug in a toaster, turn on a washing machine, use the vacuum cleaner, or run slot car racers. But the electrical energy changes into another form.

20. What form of energy do you get from the toaster?

21. What form of energy do you get in slot car racers, roller coasters, and mixers in the kitchen?

22. What happened to the form of energy each time it did useful work?

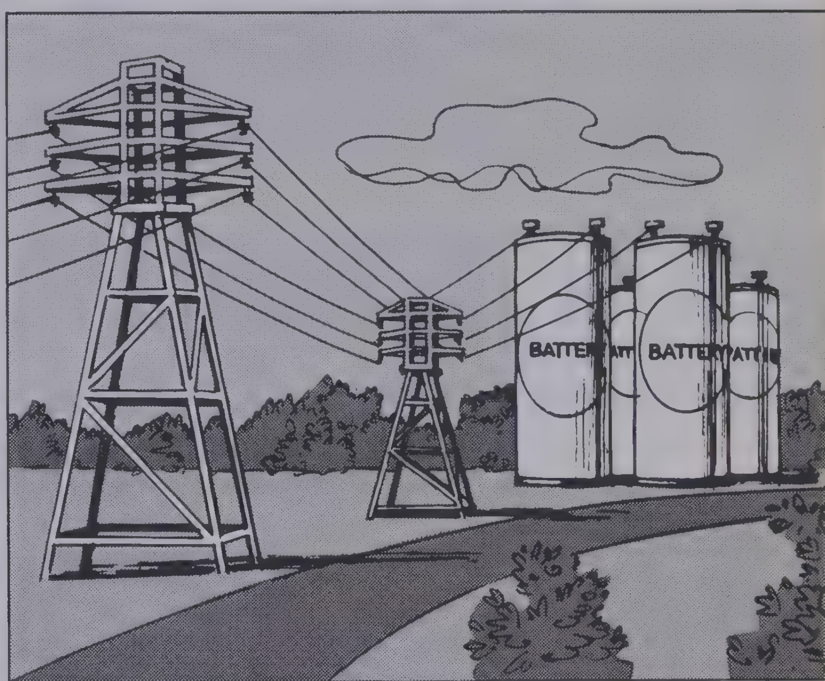
CONCEPT SUMMARY.

Investigation 5

It's Done with Wires

Electrical energy becomes motion in vacuum cleaners, washing machines, fans, and a thousand other things. It becomes heat or light in toasters, flashlights, hair dryers, and such. It becomes sound in door bells and hi-fi systems.

Most of this electrical energy in daily use comes to us on wires. We know by the monthly bill that there is an electric company at the other end of the wires. Where does the electric company get the juice? No one believes there are king-size batteries at the far end of the power lines. Power plants run on fuel, falling water, or nuclear reactors. But what, exactly, happens to make the electricity?

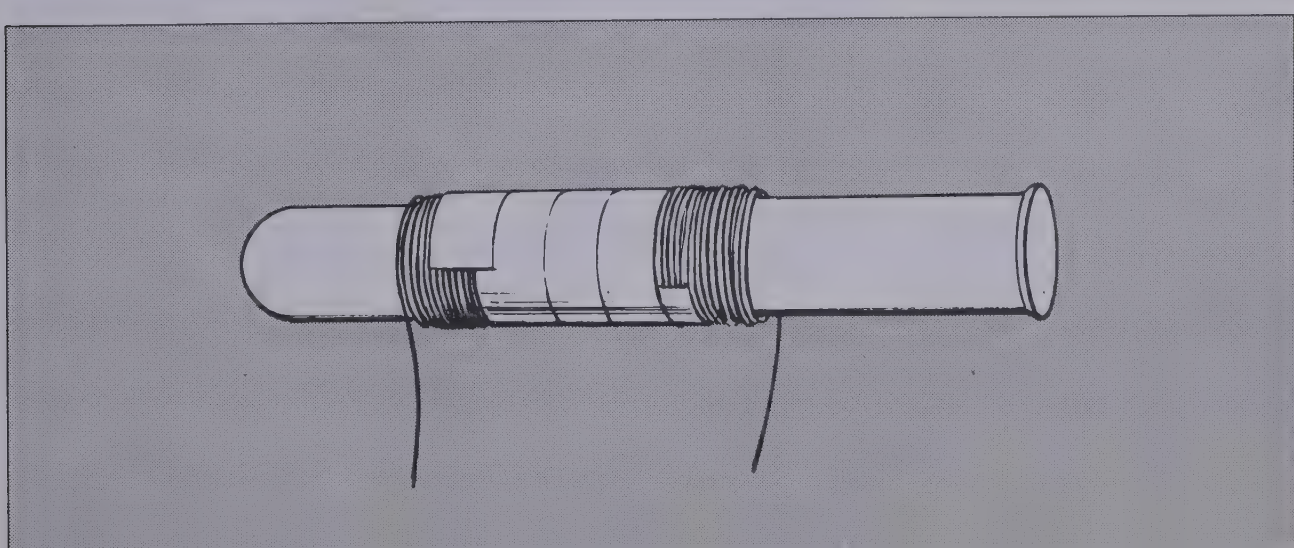


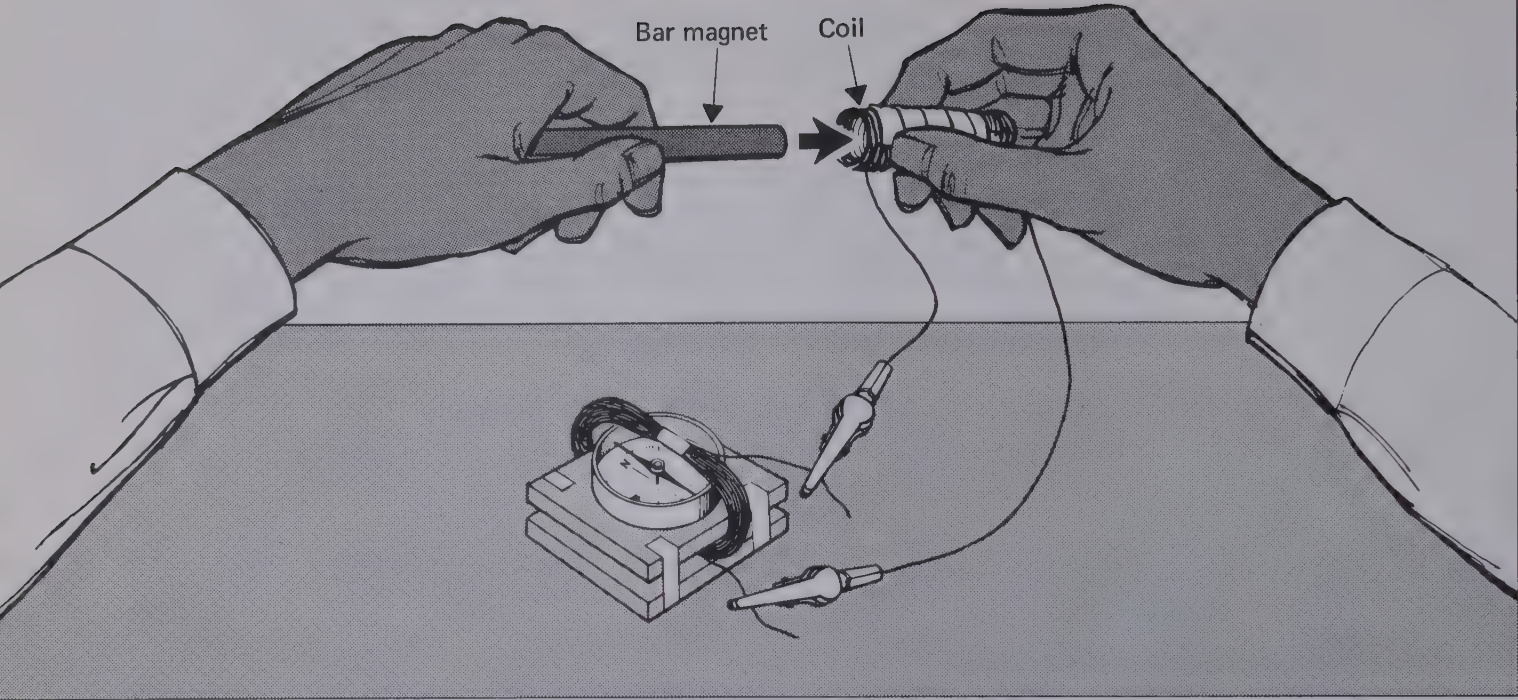
A. TURN ON THE JUICE

In the last investigation, metal strips in salt water produced electricity. This electricity produced the magnetism that moved the compass needle.

1. If electricity produces magnetism, make a prediction about what magnetism might do.

Now test your prediction. To do so, first make a magnet coil as follows: carefully wrap about 10 feet of thin copper wire around a test tube or some other object about 1½ times as big around as your bar magnet. Put masking tape around the coil to hold it together. Sandpaper away the enamel insulation from both ends of the wire.





Using electrical connecting wires, attach the ends of the magnet coil you just made to the ends of the compass coil you used in Investigation 4. Make sure the compass needle and the coil around it are placed so that both run in the same direction.

With one hand, hold onto the magnet coil. With the other, hold onto the magnet. Now watch the compass needle as you slide the magnet back and forth inside the coil. Keep the magnet away from the compass while doing this.

2. What does it mean if the compass needle moved?

3. Was electricity produced when the magnet slid back and forth inside the coil?

Reverse the process. Hold the magnet still and move the coil back and forth over the end of the magnet.

4. What does the compass needle show?

5. Did it matter whether it was the magnet coil or the magnet that moved?

6. What does the movement of the compass needle prove?

7. How would you find out whether you can produce enough electricity this way to light a flashlight bulb?

You have discovered that moving a magnet inside a coil of wire produces electricity. By this method you were able to make only a weak electric current.

8. Using the same method, what would you do to make a stronger electric current?

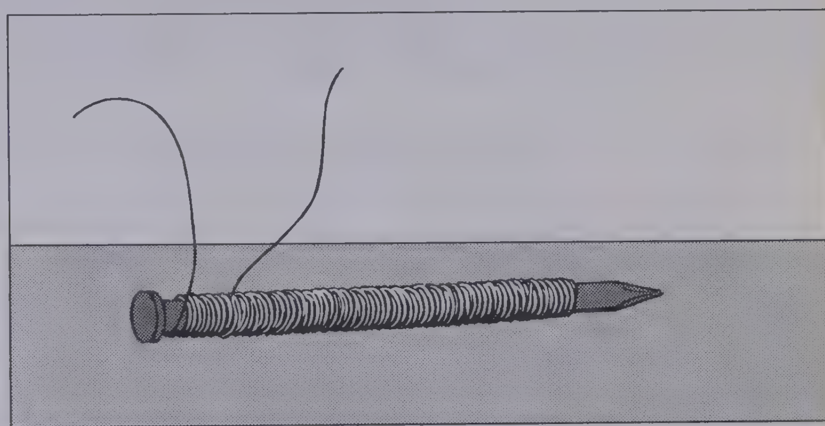
B. MAKE IT MORE COMPLICATED

Electricity can produce magnetism, and magnetism can produce electricity. So far you have used a permanent magnet. What about the magnetism produced by electricity? Can it turn around and produce electricity again?

9. What is your prediction?

Test your prediction. Take the 6-inch spike you wrapped copper wire around in Idea 3, Investigation 2. Lightly sandpaper the ends of the wire in order to make sure you'll get good electrical contact. Attach the ends of the spike wire to all four batteries in the battery pack. Test your electromagnet spike by seeing if it will lift up some paper clips.

If you haven't already done it, take the bar magnet out of the coil you used in part A. Now put the spike electromagnet into the empty coil.



10. What does the compass needle show?

Poke the spike back and forth inside the empty coil.

11. What does the compass needle show?

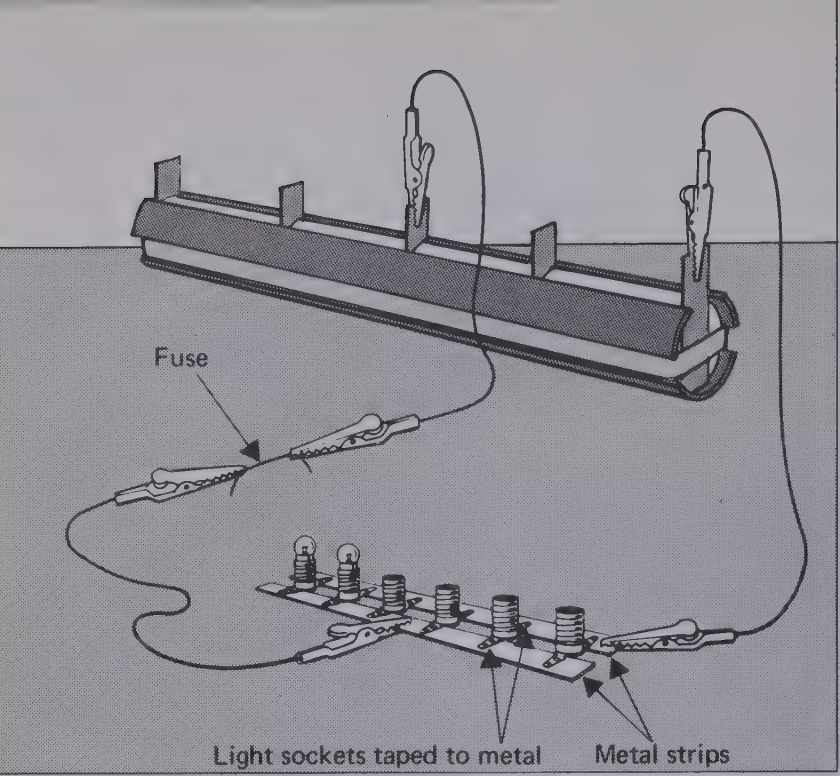
12. What difference can you see between the electricity produced by a bar magnet or the electricity produced by an electromagnet?

C. DON'T GET CONFUSED

Electricity is handy when you have it where you want it. It is not so helpful when it doesn't behave. Every now and then it gets out of line.

So we have protection from runaway electricity—fuses. Let's find out how a fuse does the job.

Robert Jordan from Black Star



Mount 6 or more empty flashlight bulb sockets so that one terminal from each is connected to one end of the battery pack. Clip the other lead to the terminal of the second battery. In this experiment you should use the juice from only two batteries. A setup like that shown with metal rulers works well, but there are lots of different ways to do it. You may know that this is called *parallel* wiring. Put a one-amp fuse into the circuit between a clip lead and a battery pack terminal.

13. Now screw one bulb into a socket. What happens?

14. Keep putting more bulbs in, one at a time slowly. What finally happens?

15. With which number bulb did it happen?

16. Why do you think it happened?

17. What can happen in more powerful circuits if there is no fuse?

18. What can happen if you connect too many extensions to one outlet at home?

19. What could happen if you use a fuse of the wrong size in your home fuse box?

D. NOTHING IS FOR FREE

You have been producing electricity with coils and magnets. Bar magnets and electromagnets will both do the job.

20. What did you have to do with the magnet inside the coil to produce a current?

21. What does it take to make anything move?

22. What has occurred when you put in mechanical energy and get out electrical energy?

23. What do the steam, falling water, and nuclear plants all supply to the generator to produce electrical energy?

24. What is interesting about electricity and magnetism, in a way like chickens and eggs?

CONCEPT SUMMARY.

Investigation 6

Motors Turn You On

Electrical energy is used for heat and light, but it goes deeper than that. Our whole man-made world runs on electricity. Whether it's doorbells or drill presses, telephones or television, electricity is what makes it go. If the electricity goes off, everything stops dead, electric motors as well as electric lights. And this brings up more questions. We know that electricity makes light by heating a thin wire so hot that it glows. But how does electricity run a motor?

Wide World Photos

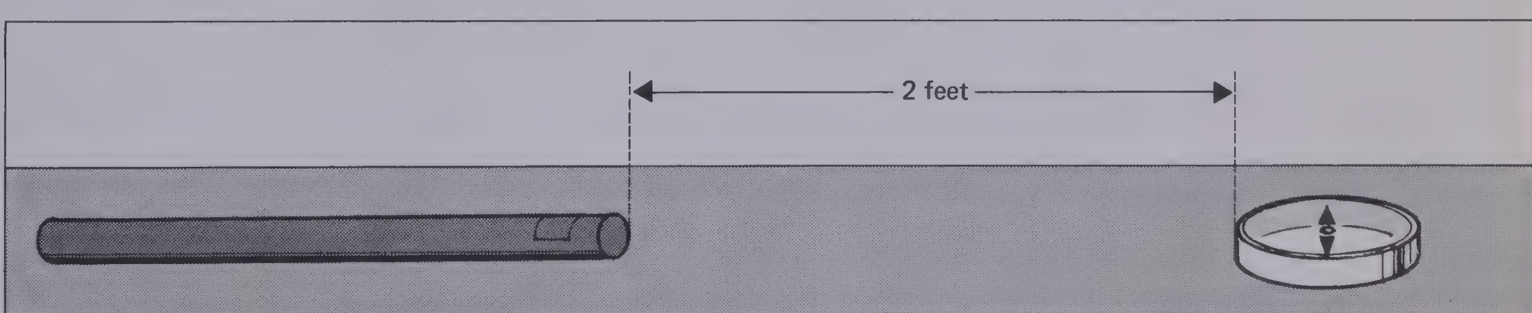
Wide World Photos

What the 1965 Blackout Did to New York City

A. COMING OR GOING?

Force is a push or a pull. Work is done when something is pushed or pulled over a distance. Does the pushing or pulling have to move something in a straight line, or can it go round and round? To find an answer to this question, let's try working with magnets.

Team up with another group so that you have two bar magnets to work with. Place one of the two magnets and the compass on the desk about 2 feet apart so that the magnet and compass needle are at right angles.



Move the magnet in toward the compass until they are about 6 inches apart.

1. Which way did the compass needle move, clockwise or counterclockwise?

Put the magnet 2 feet away again. Now turn it around so its other end is in toward the compass. Again move the magnet toward the compass until they are about 6 inches apart.

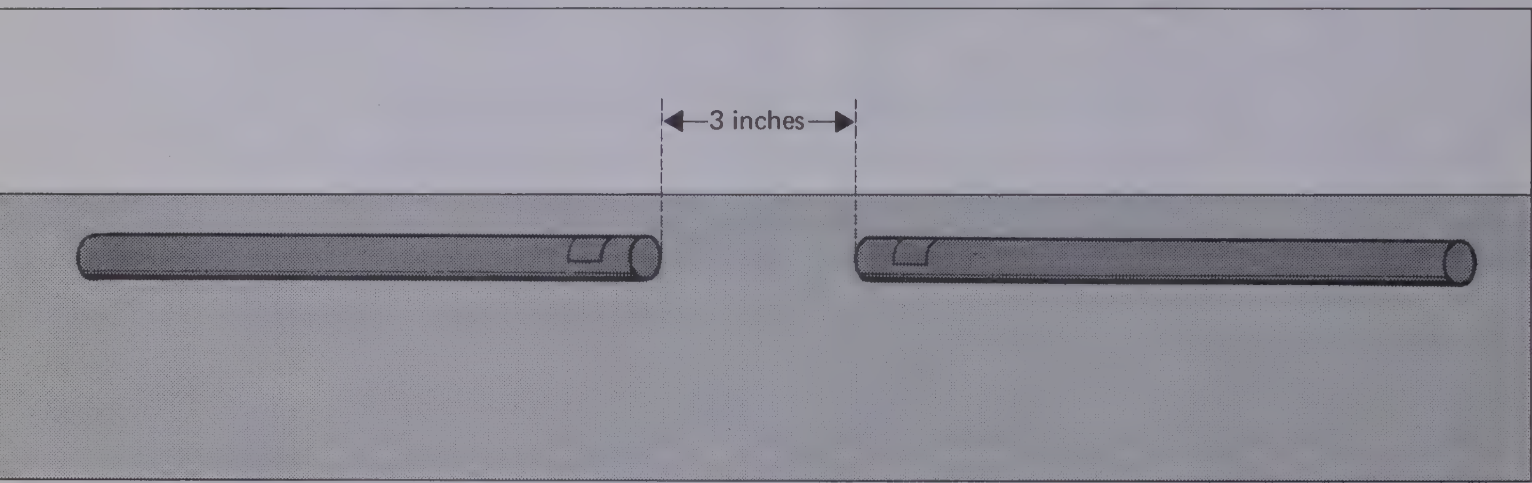
2. Which way did the needle move, clockwise or counterwise?

Mark the end that made the needle turn clockwise by putting some masking tape on it.

Remove the magnet and repeat what you just did, using the other magnet. Put masking tape on the end that makes the needle move clockwise, just as you did with the first magnet.

The ends of magnets are called *poles.* Each magnet should now have a marked pole and an unmarked pole.

Lay the magnets on the desk, the marked pole of one magnet next to the marked pole of the other, about 3 inches apart.



Gradually move one magnet toward the other.

3. What happens?

This time place them so that the *un*marked pole of one magnet is 3 inches from the *un*marked pole of the other. Gradually move one magnet toward the other.

4. What happens?

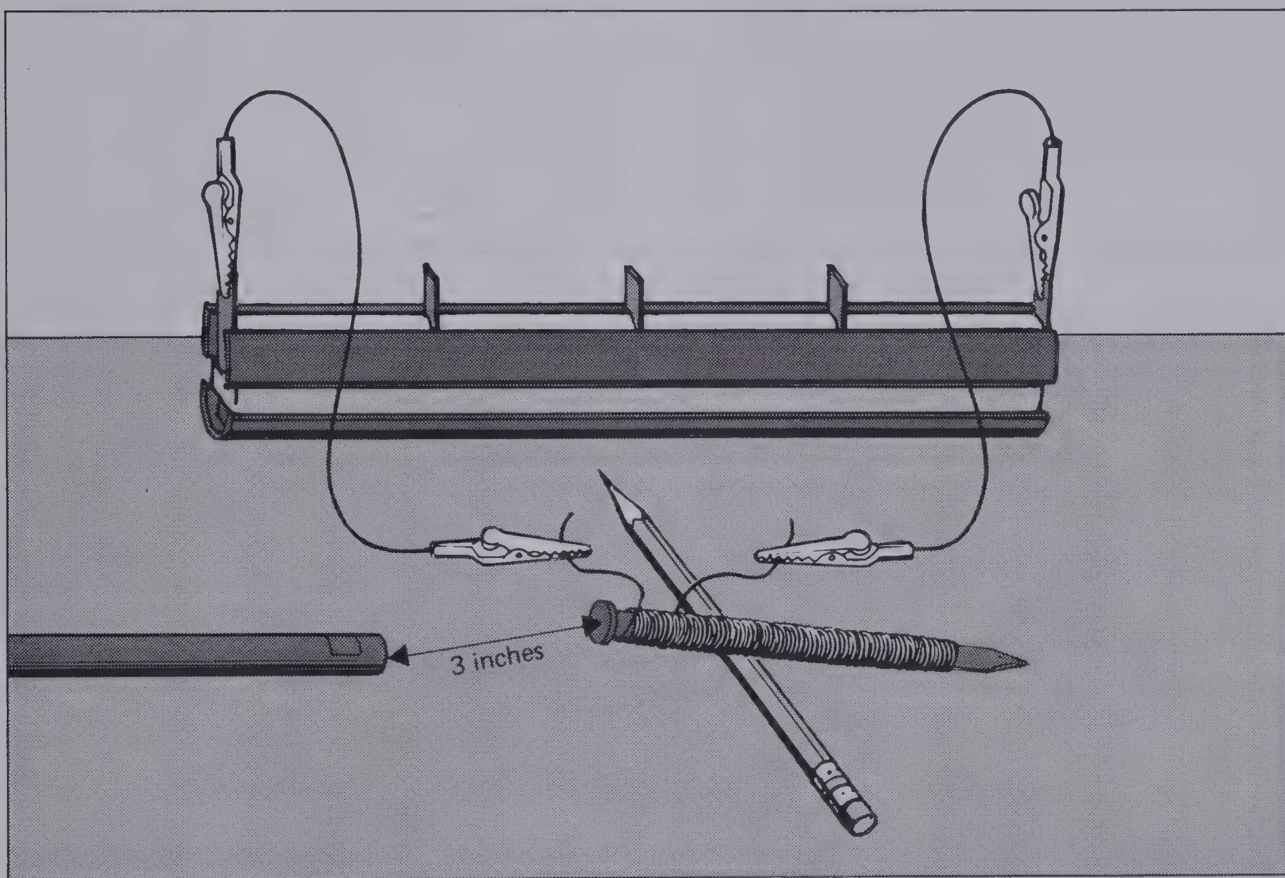
Finally, place them so that the marked pole of one magnet is 3 inches from the unmarked pole of the other. Gradually bring them together.

5. What happens?

Think back to Idea 2, Investigation 10, in which you rubbed two different types of plastic with cotton and wool cloth. When you did this experiment, you were able to sum up your observations by saying "Like charges repel; unlike charges attract."

6. What saying can you think of now that would sum up your observations about the way magnetic poles work?

Will magnetism from electricity behave the same way? Only one bar magnet is needed for this, so you can work in separate teams. Take the spike electromagnet you used in the last investigation. Balance it very delicately on top of an ordinary wooden pencil. Put your bar magnet on the table with its marked pole about 3 inches away from the head of the electromagnet. Connect the wires from the electromagnet to the four-battery power. Gradually move the bar magnet toward the electromagnet until the electromagnet starts to move. When you are finished, disconnect the battery.



7. Which way did it move, toward the bar magnet, or away from it?

8. Is the head of the electromagnet like the marked or unmarked poles?

Turn the bar magnet around so that its marked pole is gradually brought toward the electromagnet.

9. Do you think the electromagnet will move toward the bar magnet or away from it?

10. Go ahead and try it. Did you make a correct prediction?

Place the bar magnet so that the electromagnet is attracted toward the bar magnet as it is gradually brought near.

In a moment you will reverse your electromagnet wires, so that the wire now going to the front of the battery will be going to the back, and vice versa.

11. Do you predict that the electromagnet will still be attracted toward the bar magnet or will it be repelled away from it?

12. Test your prediction by reversing the wires. Did you make a correct prediction?

13. Suppose you had two electromagnets, instead of one electromagnet and one bar magnet. Do you think you could get them to attract and repel each other? Explain.

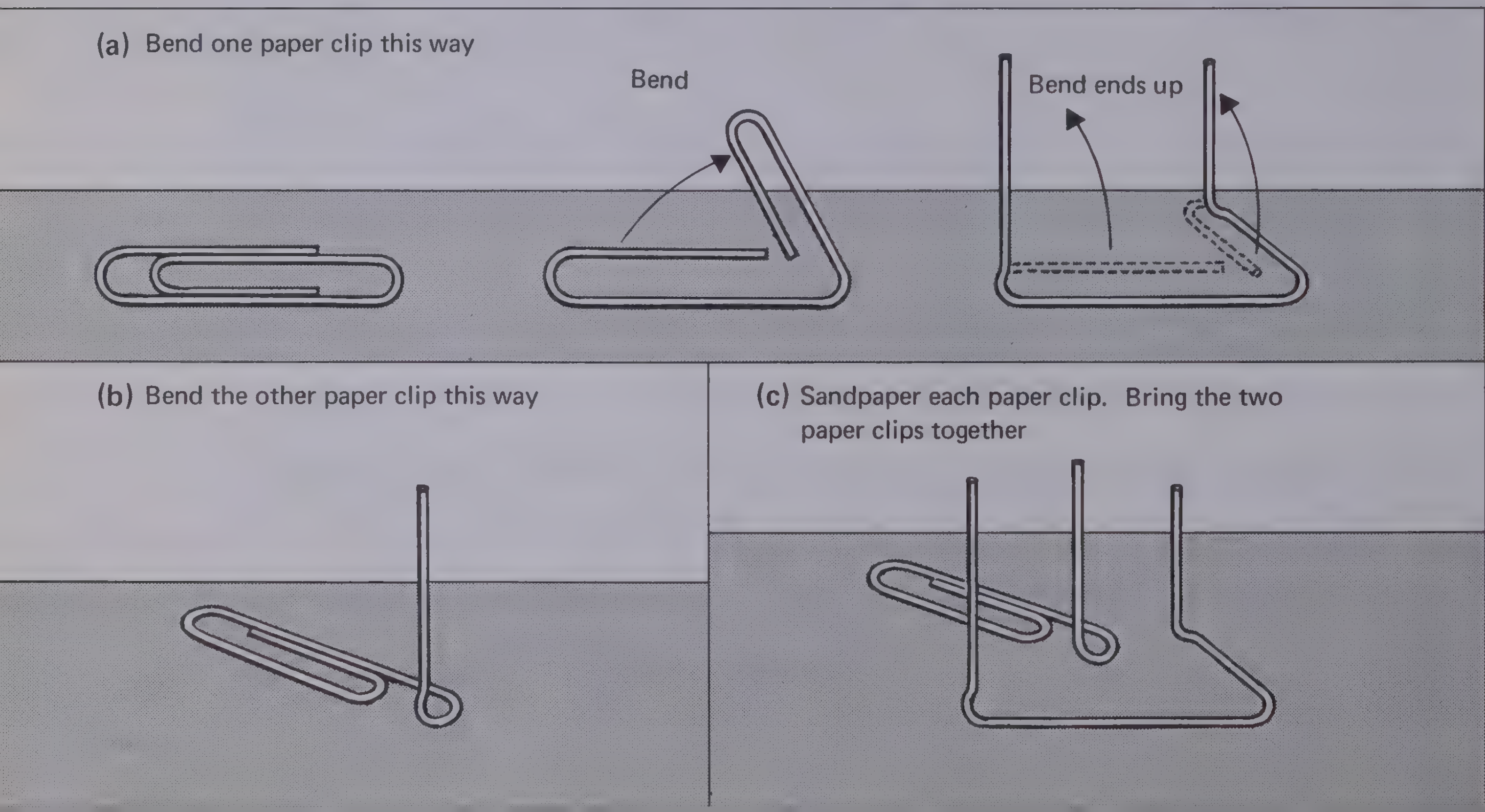
If you have time, you may be able to team up with another group and experiment with two electromagnets.

B. AROUND SHE GOES

Straight pushes and pulls turn the heat on and off in electric stoves. They ring doorbells, turn stop lights, and do many more useful jobs. But for running electric drills, buzz saws, and electric cake mixers, we need force that will make things go around and around. We need a motor.

Using some simple equipment, we can make our own motor. It will have three main parts: a switch, a bar magnet, and an electromagnet.

We'll make the switch from two paper clips.



Connect battery wires to each clip, and tape them down to the desk with masking tape, as shown.

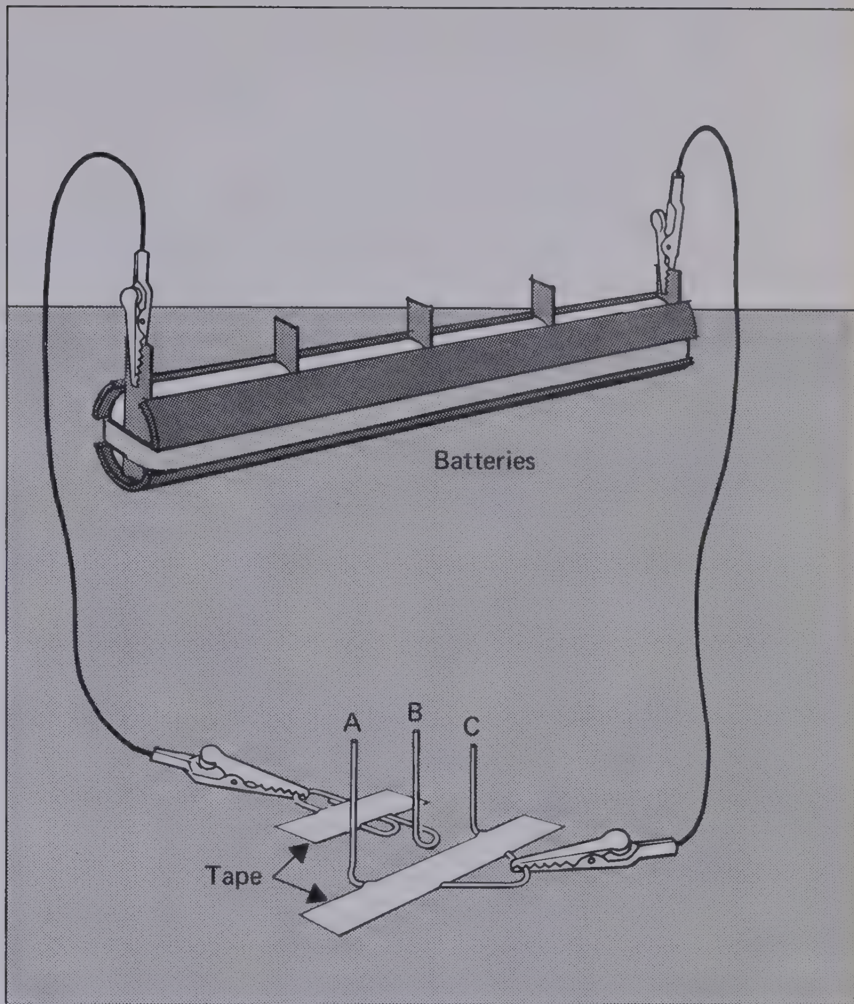
You'll see how this switch works in a minute. Now hook up your bar magnet, as follows:

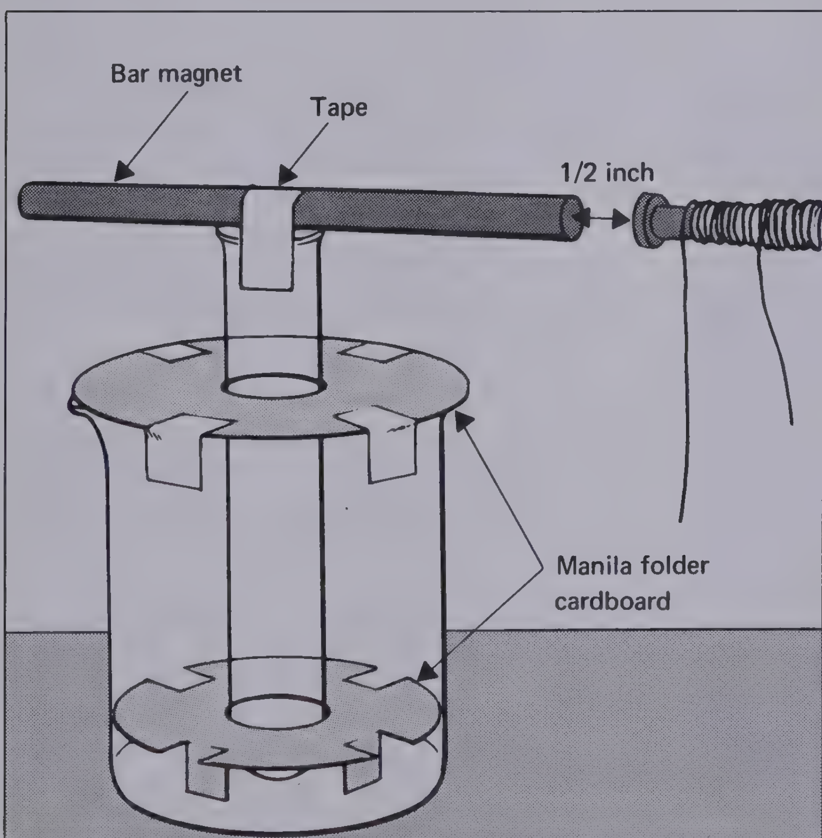
Take a look at the picture first. From cardboard (manila folder cardboard works well) cut two circles. One should just fit into your beaker, and the other should be a little wider than the top of the beaker.

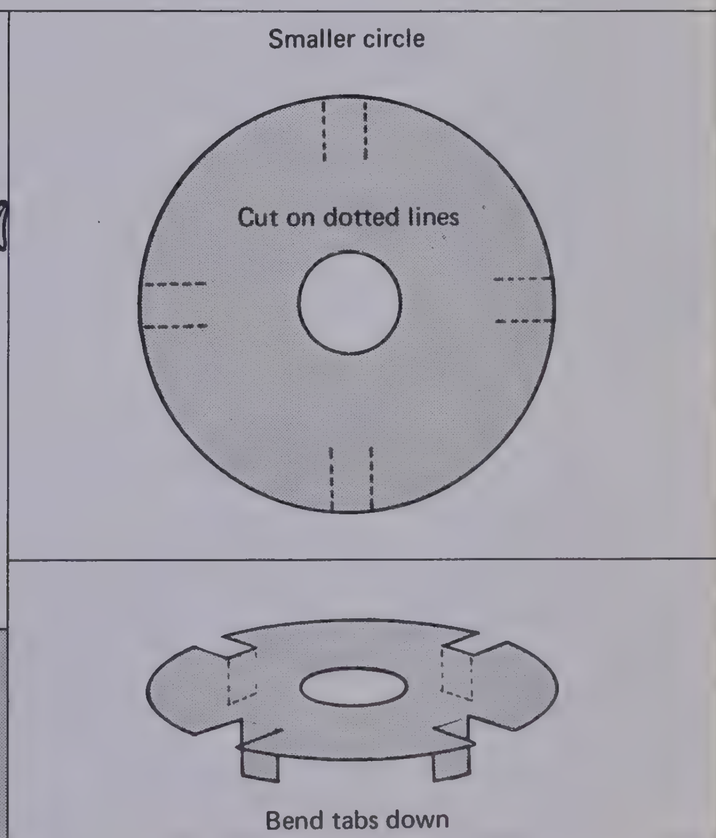
Cut holes in the center of each circle just a little larger than the size of your test tube.

On the smaller circle cut tabs, as shown. Bend these down on the smaller circle to keep it about ½ inch from the bottom of the beaker.

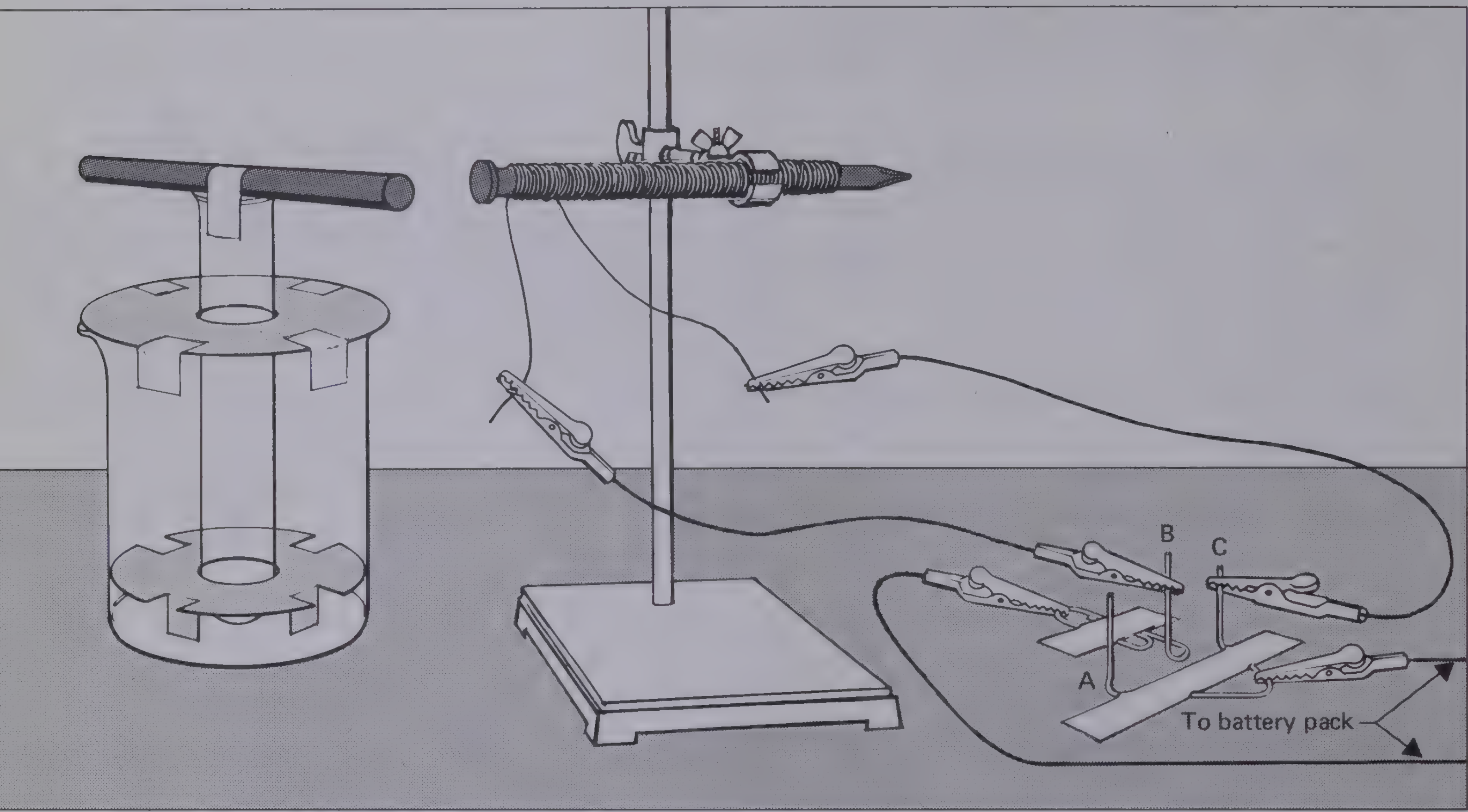
Tape the wider circle to the top of the beaker, so that the test tube will stand up as nearly straight as possible.

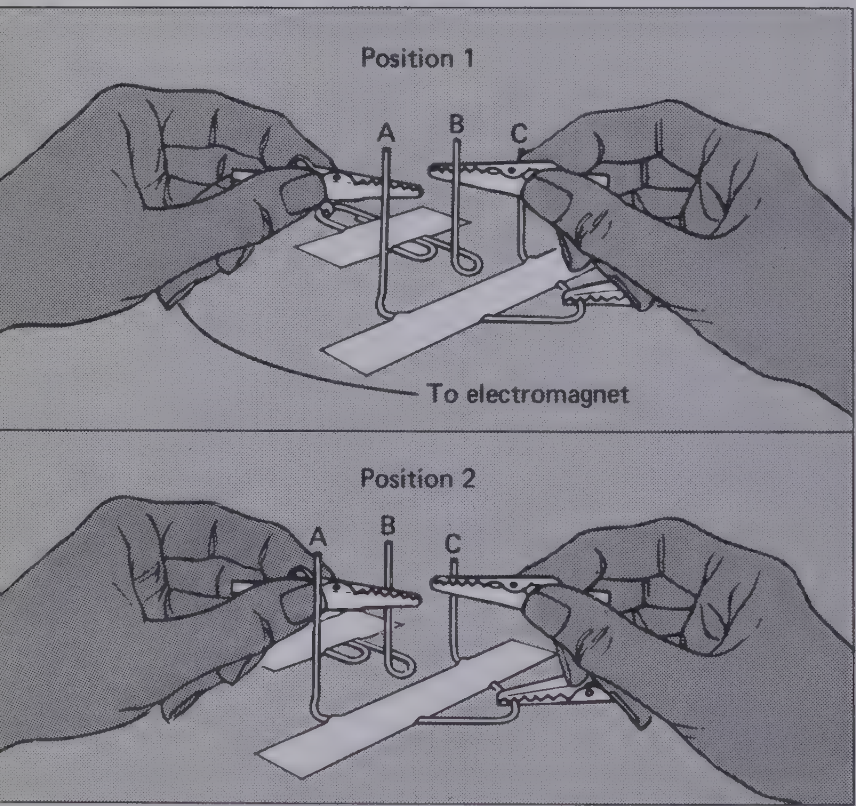






Put the test tube with the magnet on it in the beaker, and see if it will turn easily. If it does not, be sure the holes in the two pieces of cardboard are lined up. See if the holes are big enough but not too big. Fasten the electromagnet at the same height as the bar magnet.





The beaker containing the bar magnet should be placed so there is about ½ inch separation between the two when the bar magnet swings past the electromagnet.

Turn the bar magnet so that neither end is near the end of the electromagnet. Hold the ends of the wire from the electromagnet to the switch as in Position 1 for about 2 or 3 seconds.

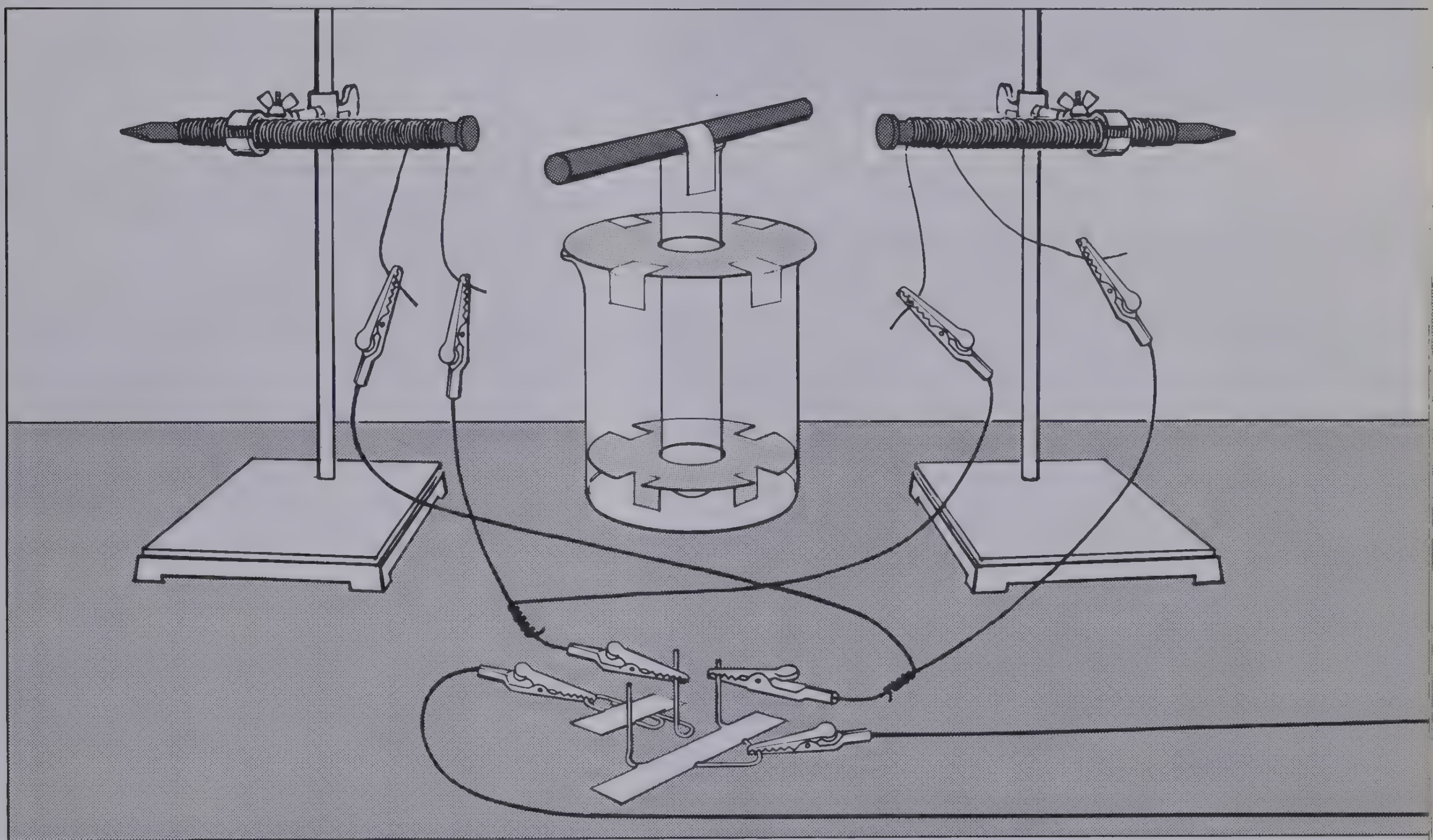
14. What happened?

Repeat what you just did to make sure you see what is happening.

Turn the bar magnet again so that its ends are the same as before (away from the electromagnet). This time hold the electromagnet wires to the switch as in Position 2.

15. What happened?

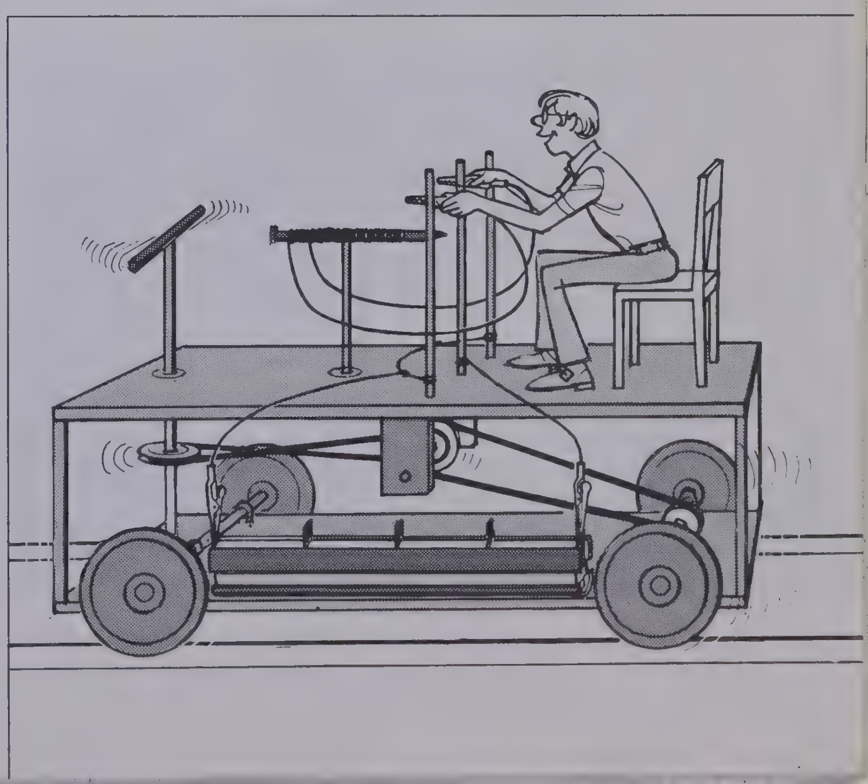
By changing the electromagnet wires back and forth between Positions 1 and 2, see if you can get your bar magnet to go around in a circle several times without stopping. It takes a little practice to get the right timing.

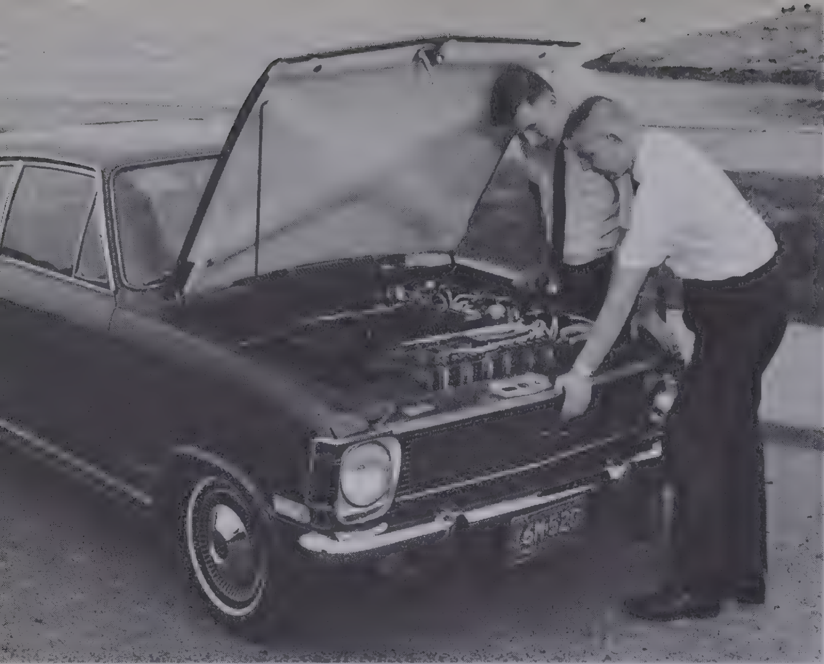


16. Suppose you placed another electromagnet on the other side of the bar magnet. What effect would this have on the way your motor ran?

If you have time, your teacher may have you team up with another group and try this.

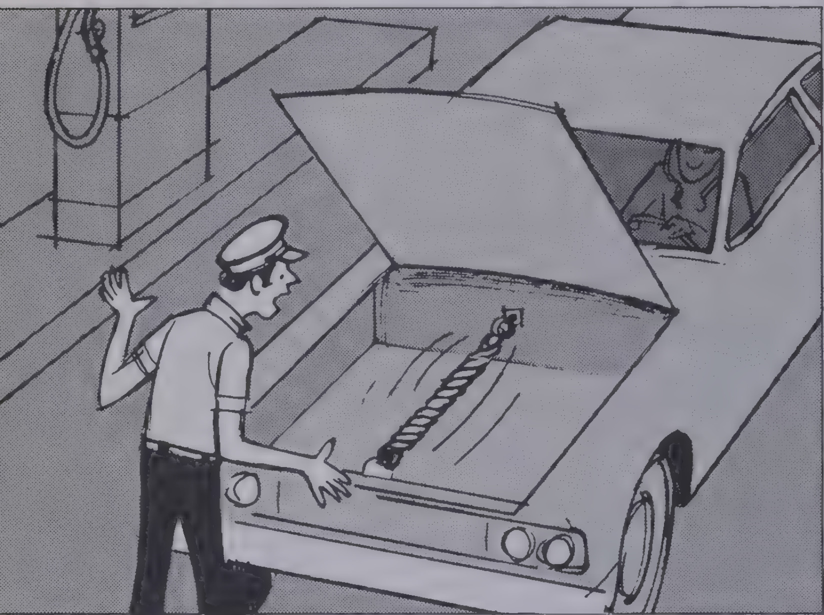
17. The electric motor you just made is not very strong. In what ways do you suppose strong electric motors (like those which run trains) are different from weak ones?





General Motors Corp.

GM Stir-Lec I



C. DOES ELECTRICITY SMELL?

Before long, it is possible that most people will be driving cars that run on batteries rather than on gasoline. So far they don't run as well as cars that run on gasoline, but scientists are working on it. Electric cars do have one tremendous advantage for people who like to breathe.

18. What do you think that advantage is?

19. About what percent of the air pollution in our cities do you think comes from motor vehicles that run on gasoline or diesel oil: 10%, 30%, 50%, 70%?

20. What will happen to people if something is not done to stop air pollution?

21. Even if there were no air pollution problem, there are advantages to finding power sources other than gasoline and diesel oil. Can you think of any of these advantages?

22. Can you think of any other power sources, besides electricity and gas and oil, that can be used to run cars, boats, and planes?

D. BACK TO WORK

Remember the scientist's definition of work? Work is done when a force pushes or pulls something over a distance.

23. What part of the definition is supplied by the interaction between electricity and magnetism?

24. What part of the definition is supplied by the turning bar magnet?

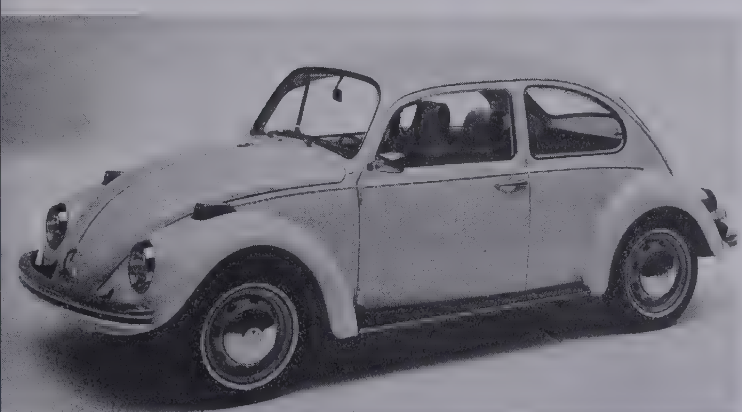
25. What is useful about the interaction of electricity and magnetism?

CONCEPT SUMMARY.

Investigation 7

You Get It Here and Leave It There

A popular car in the U.S. is the Volkswagen, made in Germany. How do all the Volkswagens get here?



Florida Photo

The cotton in your clothes most likely came from a southern state or California. And no matter where in this country you shop, you will find wheat from Kansas, beef from Texas, maple syrup from Vermont, and oranges from Florida. How did all these good things get to the shelves of your local supermarket?

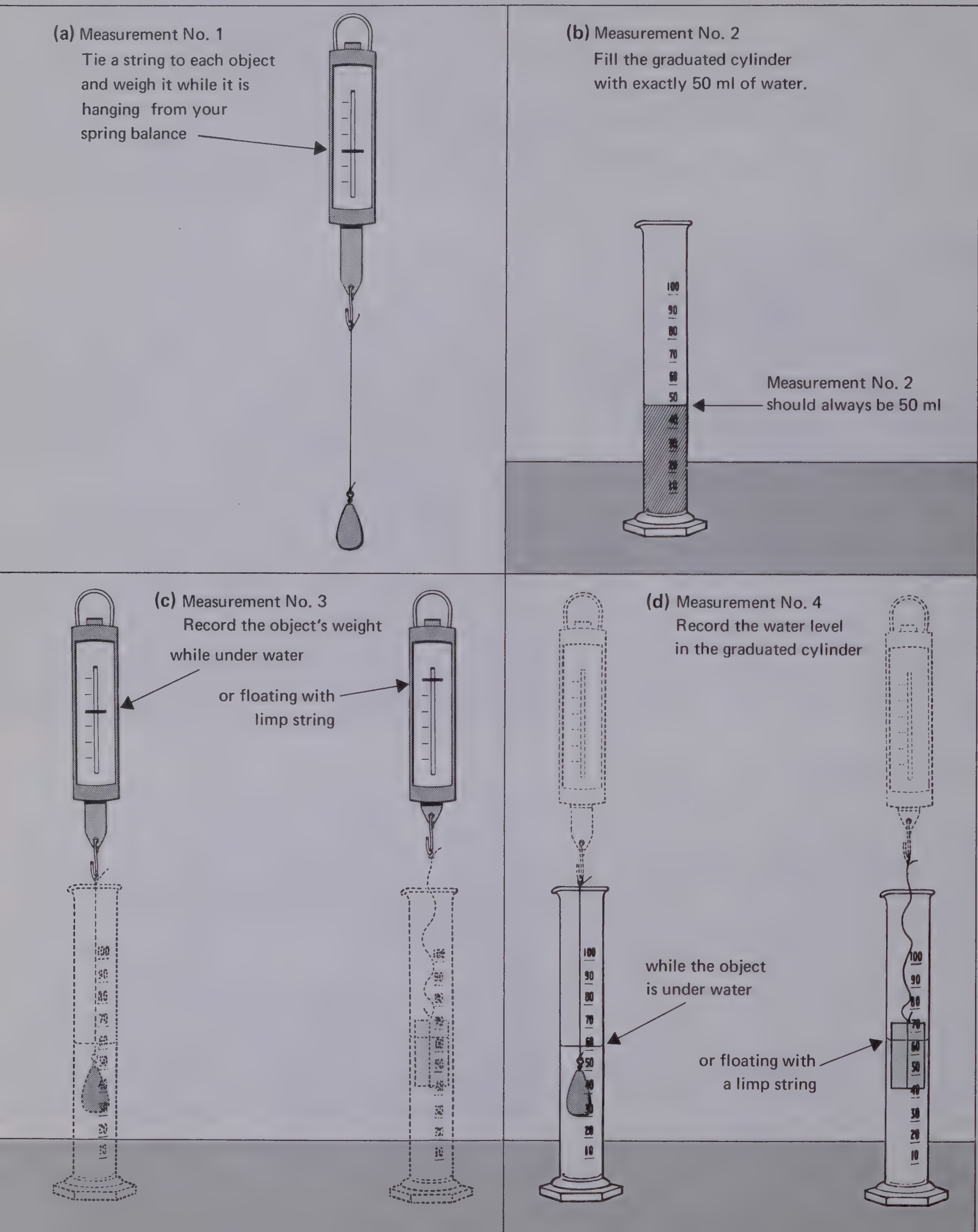
A. ALL ABOARD!

What we are talking about is transportation. There isn't time to investigate all the details of transportation, but the basic ideas are simple: something that moves and a power source to move it. There are special problems with water and air transportation. Let's look at ships first.

Cunard

Most ships are made of steel. A lump of steel won't float. You know that gravity pulls down, but what happens in water to hold up a 200,000 ton ship?

You'll be given several objects. For each object make Measurements 1, 2, 3, and 4 as pictured below. Write all your measurements in Table No. 1 on your data sheet.



When you have made measurements for all your objects, then make two calculations.

First, find the change in weight when an object is weighed in water by subtracting Measurement 3 from Measurement 1. Write this in the table.

Second, find the amount of water the object pushed aside by subtracting Measurement 2 from Measurement 4. Write this in the table.

Look at your table. It has the answers to the next few questions. It also has the answer to why ships float.

1. Do objects gain weight or lose weight in water?

Look at the two calculations. Remember, one is the change in weight. The other is the amount of water the object pushed aside.

2. How do these numbers compare?

As you may remember from earlier work, one ml of water weighs one gram.

3. When an object pushes aside a gram of water, what does the water do to the object?

4. With how much force does water push up on something that floats?

5. How can you make water push up on a piece of steel with enough force to make it float?

There is a special name for the force that pushes up on objects in water. It is called the *buoyant force.*

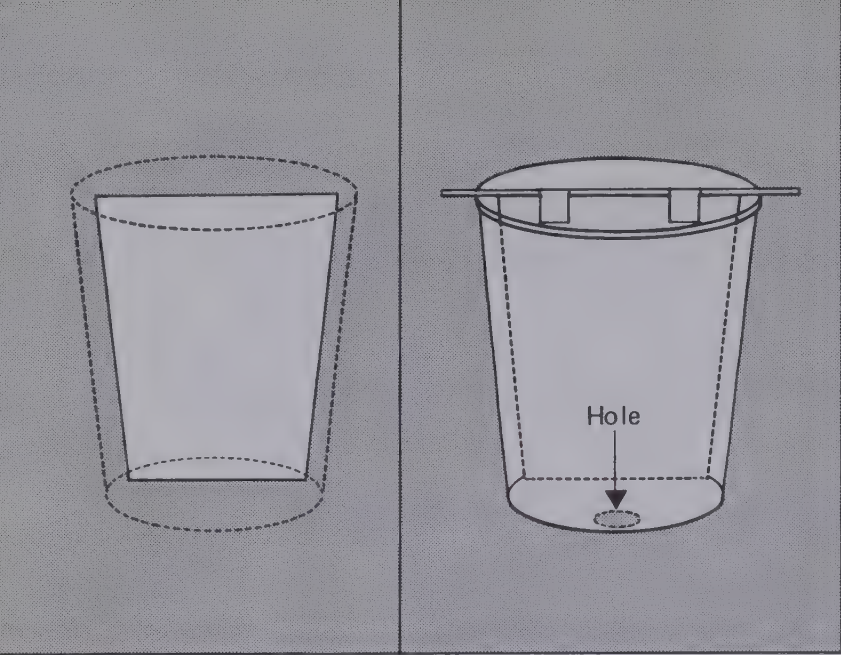
B. UP, UP, AND AWAY!

The buoyant force keeps a boat afloat. The ground keeps cars from falling. But what keeps airplanes and kites in the air?

Set a Ping-Pong ball in a funnel. Blow through the stem of the funnel to get it out.

6. What happens?

Hold the funnel upside down. Hold the ball up in the funnel. Take a deep breath. Start blowing and let go of the ball.



7. What happens?

8. What happens when you stop blowing?

Cut a piece of manila folder cardboard so that it fits into your paper cup. It should be a loose fit so that there is about ¼ inch space between its edges and the walls of the cup.

Tape the end of the cardboard to a piece of wire or a straightened paper clip.

Set it into the paper cup so that only the paper clip is touching any part of the cup.

Make a hole in one side of the bottom of the cup about the size of the thickness of a pencil (about ¼ inch).

Cover the hole with masking tape, but leave one end of the tape loose so you can remove the tape easily.

The cardboard divides the cup into two sides. Let the cardboard hang so the hole is centered on one side of the cardboard.

In a moment you will fill the cup with water and will pull the tape away so the water drains out.

9. When the water runs out the hole, what do you expect the piece of manila cardboard will do?

Go ahead and try it, but make sure you're holding the cup over something to catch the water. Also make sure that the cardboard is hanging so the hole is in the middle of one side.

10. What happened to the cardboard as the water ran out of the cup?

11. Before you opened the hole, how did the water pressure (the push of the water) on one side of the cardboard compare with the water pressure on the other side?

12. After you opened the hole, how did the water pressure on the side having the hole compare with the water pressure on the other side?

Even though we can't see air, it works a lot like water. It has pressure, too. We are most aware of the pressure of the air when we are out in a strong wind. But usually we don't notice it, even though it's all around us.

Hold a piece of paper by one end to your lower lip so it goes straight out and then hangs down. Blow gently straight outward.

13. What happened?

14. Where was the air pressure greater: on the top of the paper or on the bottom?

15. When you were blowing straight outward, where was the air moving faster: along the underside of the paper, or along the top side of the paper?

Hold a piece of paper by one end so it hangs straight down.

16. Make a prediction. If you blow on the paper downward from above, as shown in picture (a), do you think the paper will move toward you or away from you?

17. Try it. What happened?

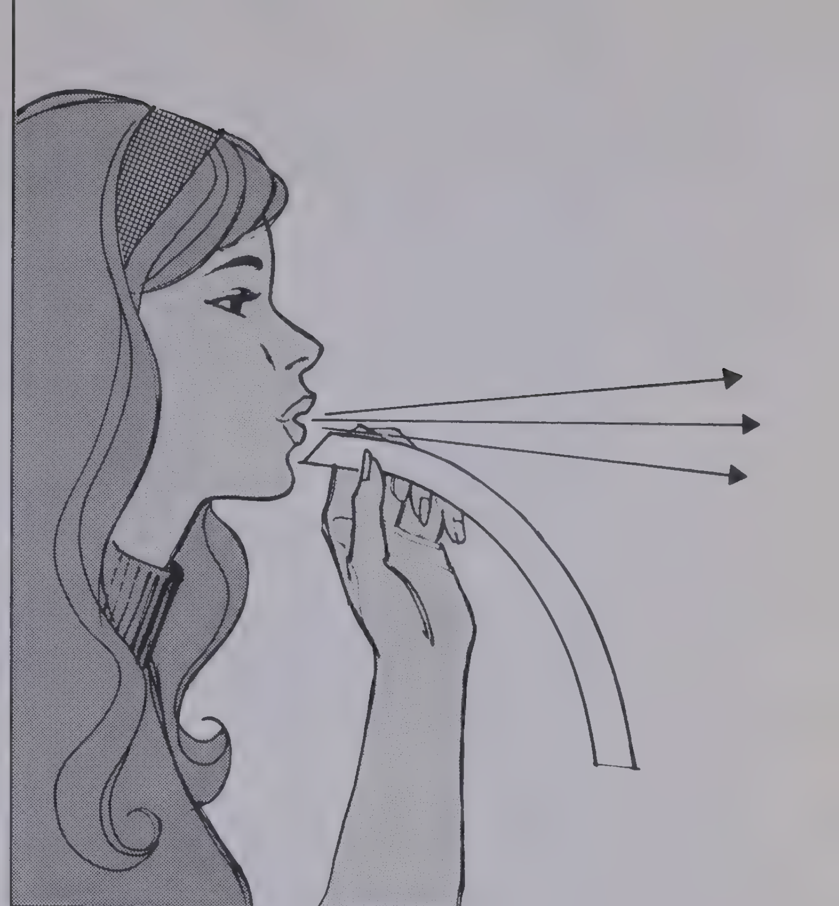
Now try something just a little bit different. What do you think will happen if this time you blow straight downward as shown in picture (b)? Notice that all your breath will go alongside the paper. None of your breath will actually hit the paper.

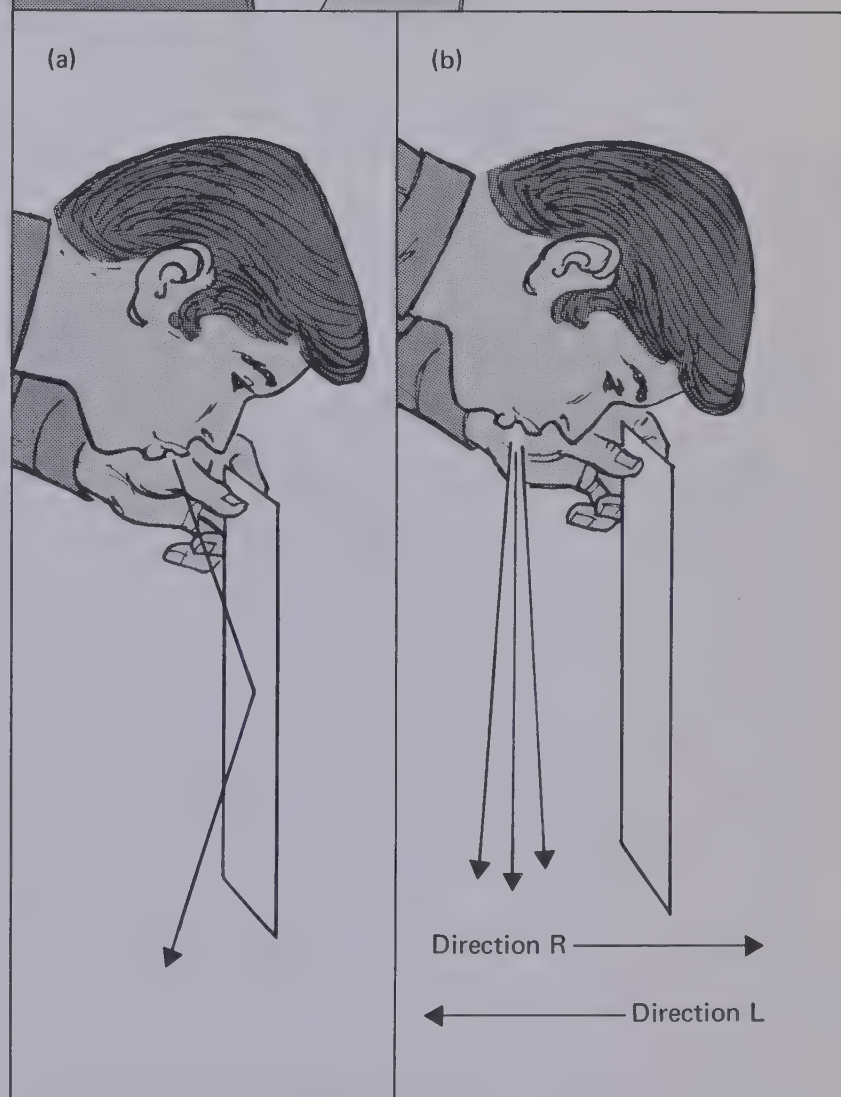
18. Make a guess. Will the paper move in Direction L or in Direction R?

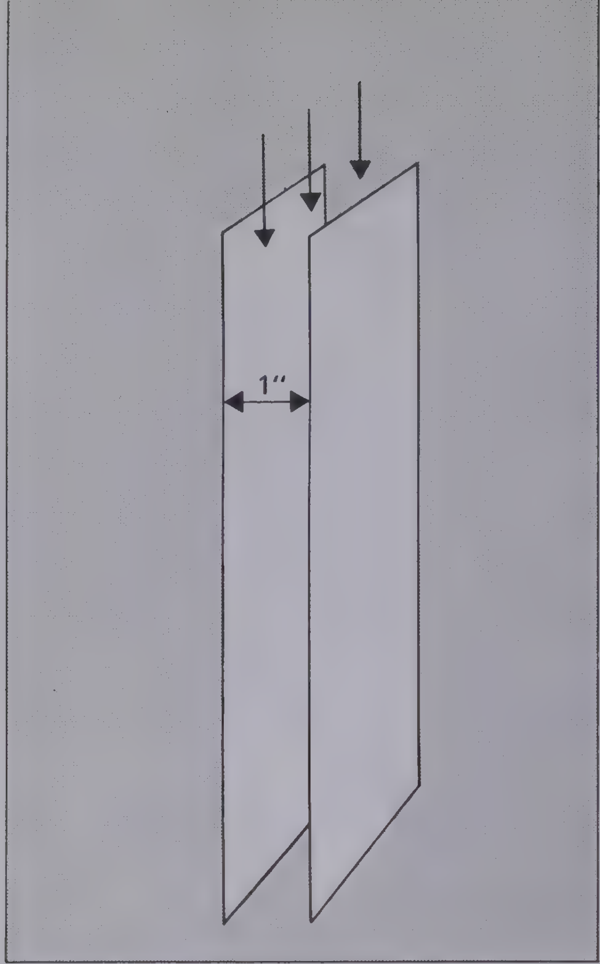
Now see what actually happens by holding the paper straight down from your eyebrows. Remember to blow straight down alongside the paper, but not on it.

19. What direction did the paper move, in Direction L or in Direction R?

20. Was the air pressure pushing harder against the paper on the side you blew along, or on the other side?







21. Is air pressure pushing harder along the side where air is moving faster, or along the side where air is moving slower?

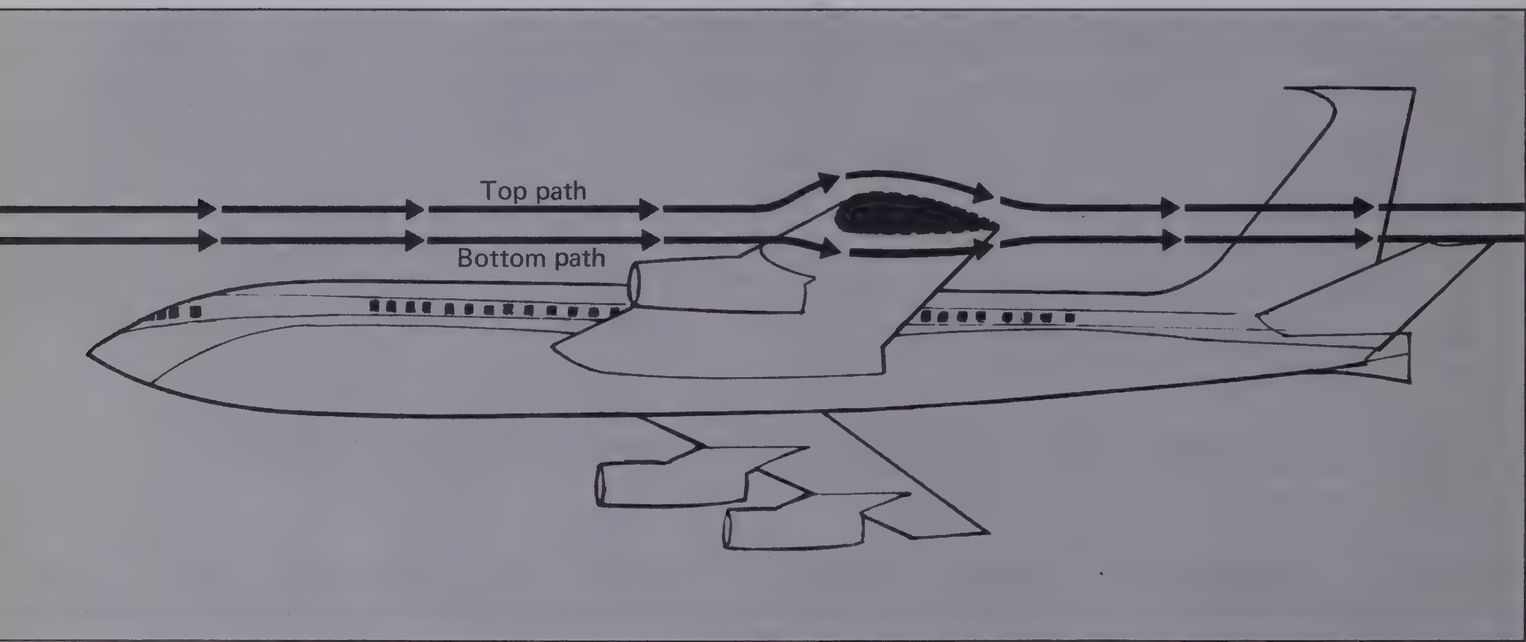
Now you can test yourself to see how well you understand air pressure. Hold two pieces of paper by their ends about one inch apart.

22. If you blow straight down between the two, where will the air be moving faster, on the inside of the two pieces of paper or on the outside of the two pieces of paper?

23. Prediction: If you blow straight down between the two, will they move together or apart?

24. Try it. What happened?

Let's get back to airplanes. Here is the outline of the shape of a typical airplane wing. As the wing moves, air passes above and below it.



25. Air sweeping by the wing of a plane can go along the top of the wing or along the bottom of the wing. Which path is the longer path?

26. It takes the same length of time for air to move along the top of the wing as it does to move along the bottom. Where does it move faster then, along the top of the wing or along the bottom of the wing?

27. Where is the air pressure greater, on the top or the bottom of the wing?

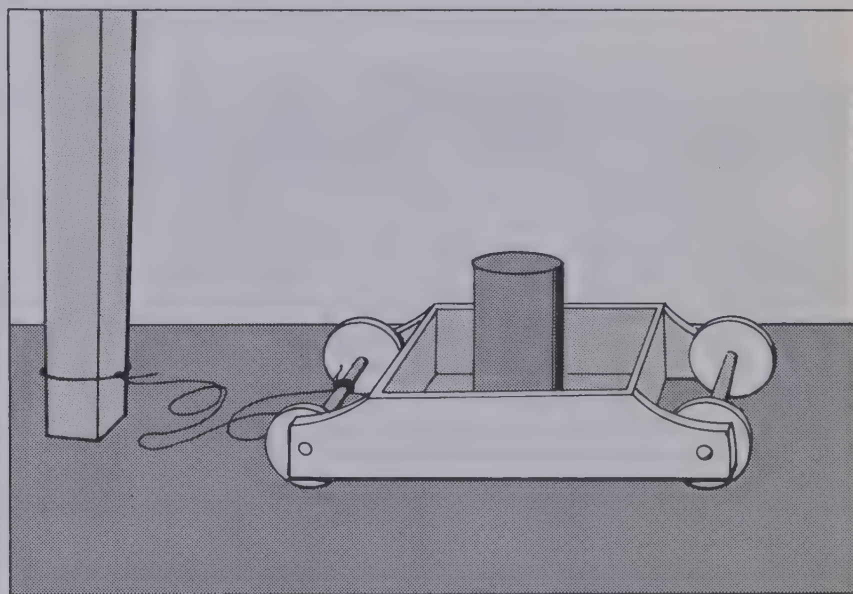
28. What holds an airplane up?

C. IT'S THE STOP AT THE END

Moving around causes problems. Take the automobile. Every year, besides polluting the air, cars kill 50,000 people in the United States. Is it just going fast that does the killing?

Of course not. Lots of people have gone 600 miles per hour in jet planes without getting hurt in the least bit. Maybe we should look at the stopping, not the going.

Stand the metal cylinder on its end on your truck. Give the truck a quick push to start it.



29. What happened to the cylinder?

Tie some string to the truck. Tie the other end to a table or desk leg. Put the cylinder on end on the truck. Get the truck moving, but hold the cylinder so it doesn't fall over while you're getting the truck going.

The truck will stop when the string becomes straight.

Syd Greenberg from dpi

30. What happened to the cylinder when the truck stopped?

31. Why wear a seat belt?

Resting objects tend to stand still unless a force gives them the push or pull that will start them moving. Moving objects tend to continue moving unless a force slows them down. This tendency for objects to continue standing still or to continue moving is called *inertia.*

32. Safety engineers must understand inertia. Why should car drivers know about it?

D. SOMEHOW WE GET THERE

Cars, planes, and ships all turn energy into motion, but it takes more than just a big engine.

33. To get a steel ship to float, what must the ship do with the water?

34. To get a plane to fly, what must the wing do with the air?

Once again we are talking about interactions. Floating ships are solids interacting with liquids. Flying airplanes are solids interacting with gases.

Solids, liquids, and gases are the three states of matter.

35. What do we have to understand to make transportation work?

CONCEPT SUMMARY.

Investigation 8

Making the Big Sound

Now that the job of moving things from place to place has been taken care of, another problem has to be solved. Whether it's a truckload of new hardtops or seamless nylons, people have to know when a load is on its way. The warehouse manager has to make room and assign space to the order. The advertising department has to know so they can organize a sales campaign. The salesmen have to be ready. Finally, the public has to know or they won't turn out to look and buy.

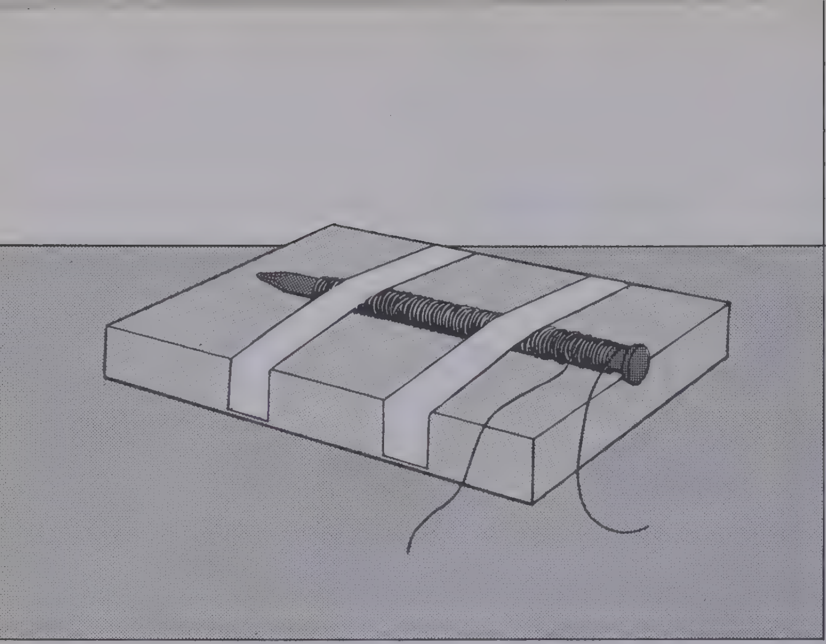
Chevrolet Motor Division

Lew Merrim from Monkmeyer Press Photo Service

How do they all find out? The word is *communication.* Communication means talking, letters, and carrier pigeons. It also means telegraph, telephone, radio, and television—all powered by electricity. Start with the simplest—telegraph messages.

A. CLICKETY CLICK

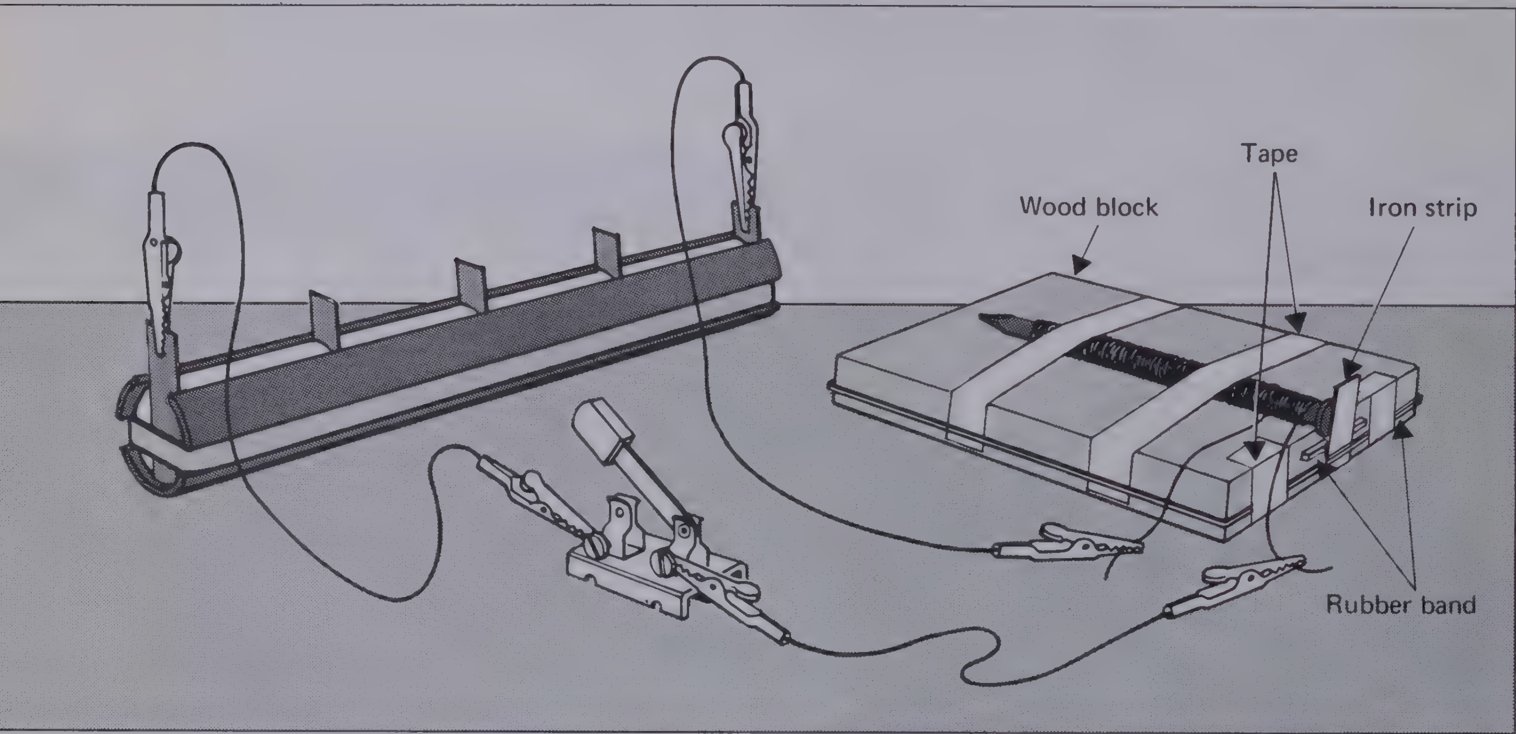
S.F.B. Morse tapped out the first telegraph communication in 1844 in *Morse Code.* There have been lots of improvements since, but the main idea is still the same.



Fasten the spike electromagnet you used in Investigation 6 on the block of wood with masking tape. The head of the spike should stick out over the end of the block of wood a short distance.

Put a rubber band around the edge of the block. Fasten the rubber band to the end of the block with masking tape.

Insert the iron strip and the piece of rubber band, as shown.



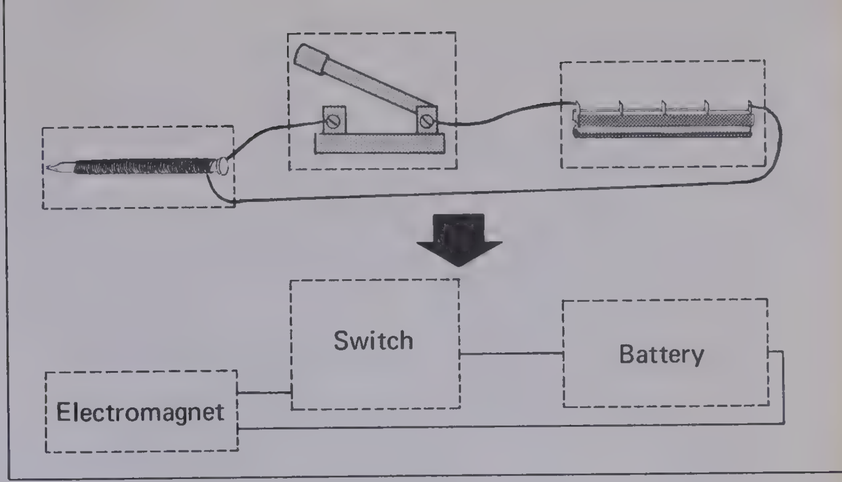
Open the switch, if it is not already open. Connect it and four-battery power to the electromagnet, as shown.

Adjust the iron strip and the piece of rubber band so that the iron strip will hit the head of the nail when the switch is closed, and so it will fall back when the switch is opened.

1. Why does the iron strip (called the *sounder*) move to the head of the nail when you close the switch?

2. Why does the sounder spring away when you open the switch?

3. Suppose you have the switch in your house and your friend has the sounder in his house. What would the two of you have to agree on before you could send a message to him?



An example of a labeled block diagram

Connect your system with the next table so you can send to them and they can send to you. Use the blank space on the data sheet to draw a diagram of how to do it. Use labeled boxes for the parts and lines for wires. See the example of a labeled block diagram for a setup like the one you just used.

4. Why can't both tables send messages at the same time?

5. What does electricity produce that makes these clickers possible?

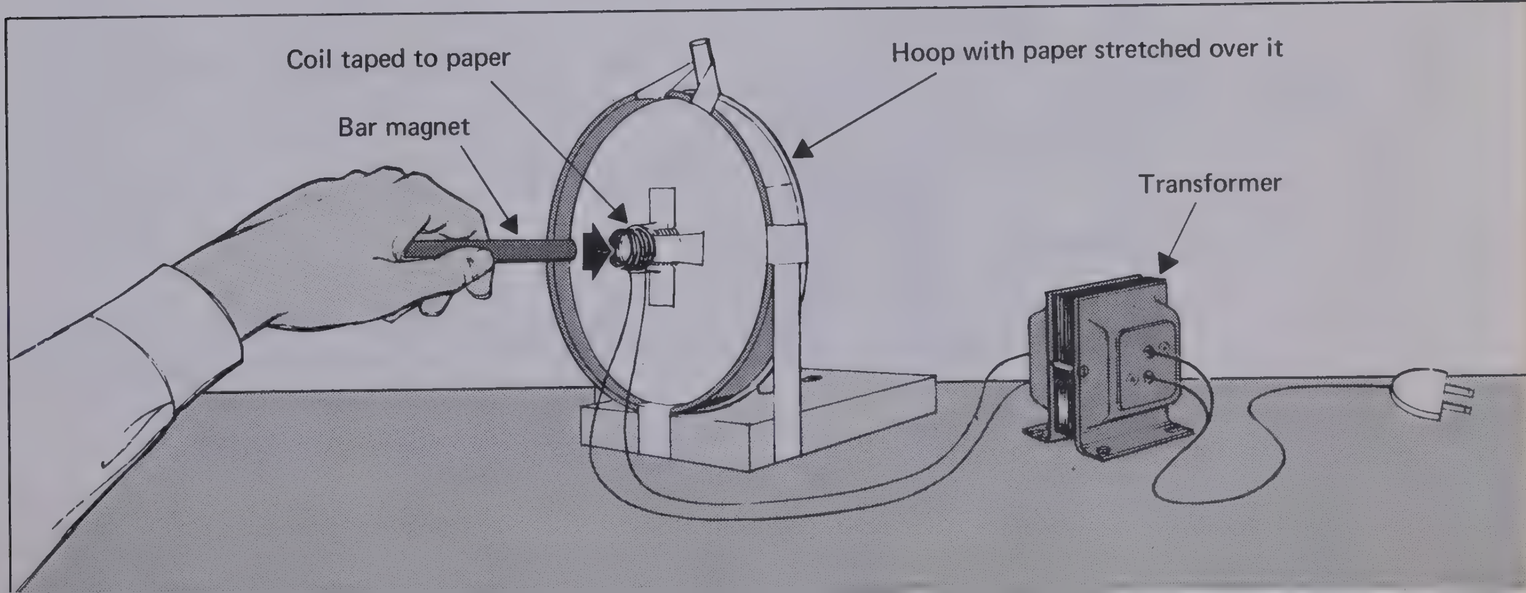
B. WHO EVER HEARD AN ELECTRON?

What do you do when you turn on a radio? You listen. You listened to the sounder in the telegraph system. You listen to a tape deck. You listen to a record player. You listen to a telephone.

All of these sound-producers run on electricity. But you can't hear electricity. This means they all change electrical energy to something else—sound. How?

The clicks from your sounder provide one clue. Another comes from the bar magnet that you got spinning around in Investigation 6. Remember when you alternated the magnetic field of the coil by switching back and forth between Positions 1 and 2? Now use electricity that is already changing direction 120 times a second. The metal box you will use to do this is a *transformer.* It cuts the voltage down enough to keep you safe.

Assemble your equipment as shown. Tape the coil to the center of the paper on the hoop. Connect the coil wires to the transformer, but don't plug it in until all is ready. When all connections have been made, plug the transformer into the electric outlet. Move the end of a bar magnet slowly in and out of the coil so that it almost touches the paper. Do this until you hear something.



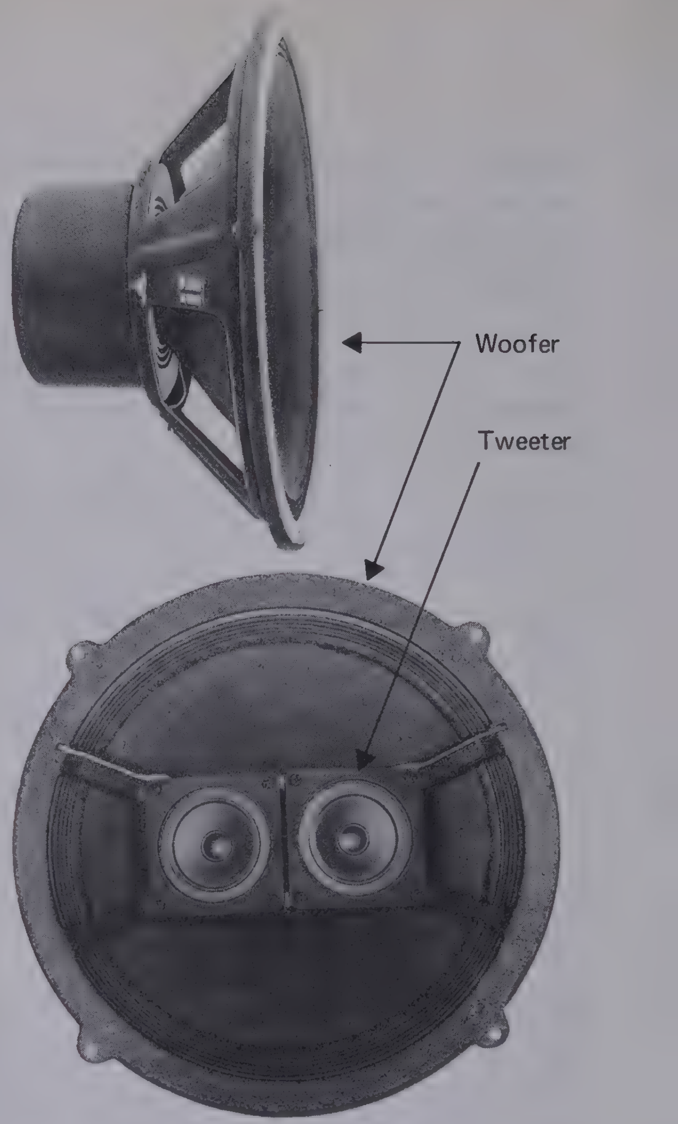
6. What do you hear?

7. What have you made with coil, paper sheet, magnet, and transformer?

8. What interaction makes it work?

C. CUT IT DOWN TO SIZE

The setup you just made is not very portable. You know that speakers come in larger sizes and smaller sizes. There are the big boomers on the amplifiers that guitar players use. There are tiny speakers in your transistor radio. Transistor radios can also be equipped with earphones. See how this is related to the speaker you made. Touch the wires from the earphone to a battery.



The R T Bozak Mfg Co

9. What happens?

Try hooking up the earphone to the transformer. Sound familiar?

10. What do you hear?

The earphone gives the same results as your homemade speaker. What is inside that does the work? Unscrew the cap with the hole in the center. The thin disk of steel underneath is called the *diaphragm.* Take it off carefully so that you don't bend it.

11. What holds the diaphragm on?

12. What is inside the earphone?

13. What does an electric current produce when it flows through coils of wire?

14. What interaction makes an earphone work?

15. The telegraph sounder, the speaker, and the earphone all operate on electric current. What does electric current produce in all of them?

16. What two things interact to convert electrical energy to sound?

CONCEPT SUMMARY.

Investigation 9

Sorry, Wrong Number

Patterns of electrical current can be changed into sound. Whether it's the tiny earphone on your transistor radio or the big multiple speakers on a fancy hi-fi system, electricity and magnetism are always on the job. We know how the sound comes *out* of the electrical equipment. How does it get in?

A. SOUND YOUR NOTE

Start with sound itself. You know that it is a kind of wave traveling through the air to reach your ears, but just what is happening?

Hold one end of a springy ruler on the edge of the table. Let about 12 cm of it stick out over the edge. Hold it firmly at the edge of the table. Pull the end down a little and let it go.

1. What do you hear?

2. What did the ruler do to produce this sound?

Shorten slightly the amount of ruler sticking out and twang it again.

3. What do you hear that is different from before?

4. Is the ruler moving faster or slower?

Shorten the ruler still more and flip the end again.

5. How does this sound compare with the others?

6. How does the speed of the ruler this time compare with the other two times?

Sybil Shackman from Monkmeyer Press Photo Service

Not many musicians play rulers, but there are a lot who play guitars, violins, cellos, and basses. All of these instruments have strings.

You can show how strings work with a simple setup. Put a rubber band around a book. Slip a pen or pencil under the rubber band and center it. Pluck the rubber band on either side of the pencil.

7. How do the two sounds compare?

Move the pencil toward one end. Compare the sound on the short side with the sound on the long side.

8. Which gives the higher note?

9. Which is moving faster?

10. What do you call what the rubber band is doing when it's moving back and forth? Hint: It starts with a *V*.

11. What do you think the air does when it carries sound?

12. What do you think your eardrum does when it picks up sound?

13. If patterns of sound are going to be changed to patterns of electrical current, what must the electrical current do?

B. MY RESISTANCE IS LOW

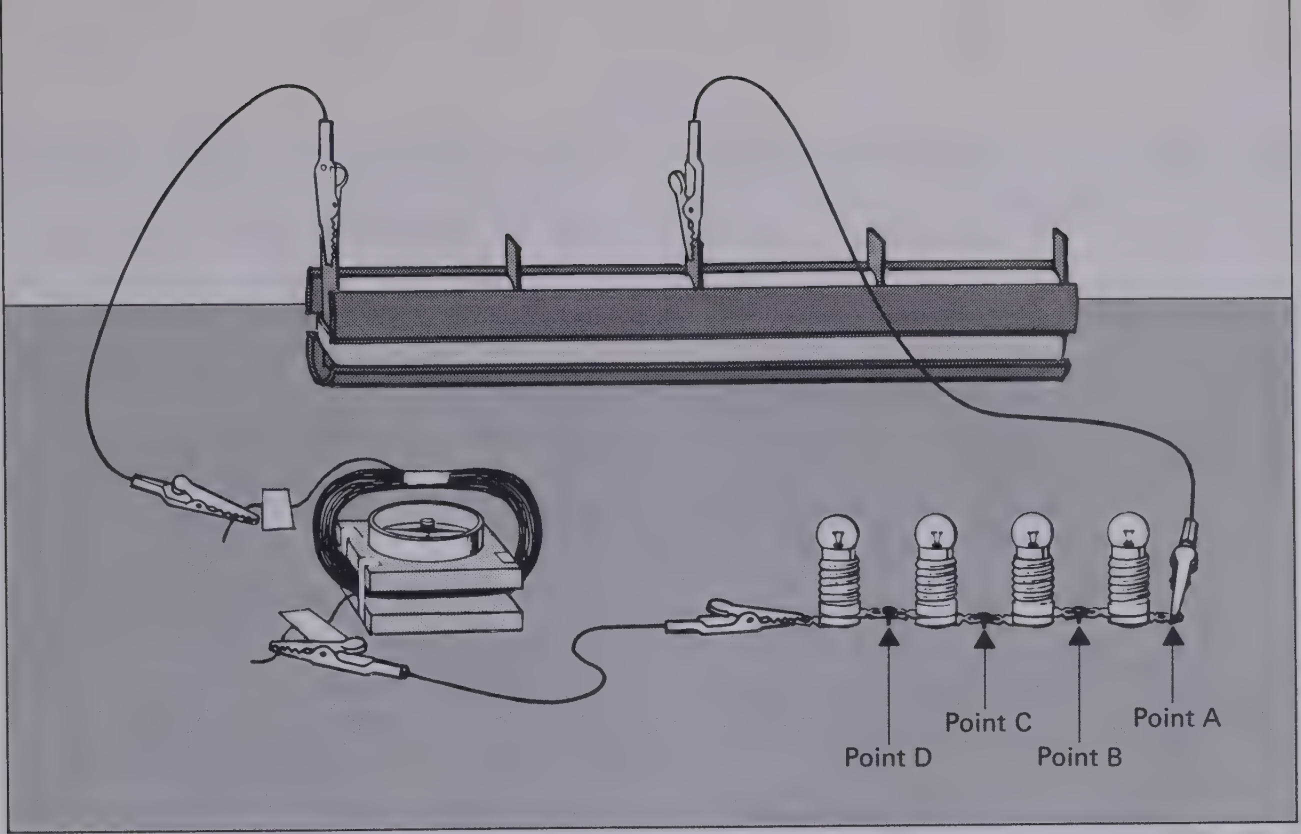
Now that the music lesson is over, back to electricity. In Investigation 5, you connected more and more flashlight bulbs in *parallel* until the fuse wire melted. Now you will connect them in a different way—in *series.* As you will find out soon, bulbs in series act differently than bulbs in parallel.

Now connect your four bulbs in series as shown in the picture.

Rotate the compass stand so that the needle and the wire of the coil run in the same direction.

Now turn only the compass so that the needle is pointing to zero.

With your finger, tap the compass gently to make sure the needle is really pointing to zero and is not just stuck there. Turn it some more to get it to zero, if you have to.



With masking tape, tape the compass coil wires down to the desk.

Connect together the battery pack (at two-battery power), the compass coil, and the bulbs as shown.

Hook up the alligator clip to point A, and watch the compass needle. You want the needle end that was pointing to zero to swing to the right. If it swung to the left instead, reverse the connections to the battery.

With the alligator clip connected to point A, wait until the needle stops moving. Tap the compass gently.

14. The amount the needle moves depends upon how much electricity passed through the four bulbs. At what number is the needle pointing?

15. Now connect the alligator clip to point B to see how much electricity is passing through three bulbs. At what number does the needle now point?

16. Connect to point C for two bulbs. At what number does the needle now point?

17. Repeat for point D. At what number does the needle now point?

The more electricity that goes through a bulb, the brighter it burns. Also, a greater amount of electricity will push the compass needle farther from zero.

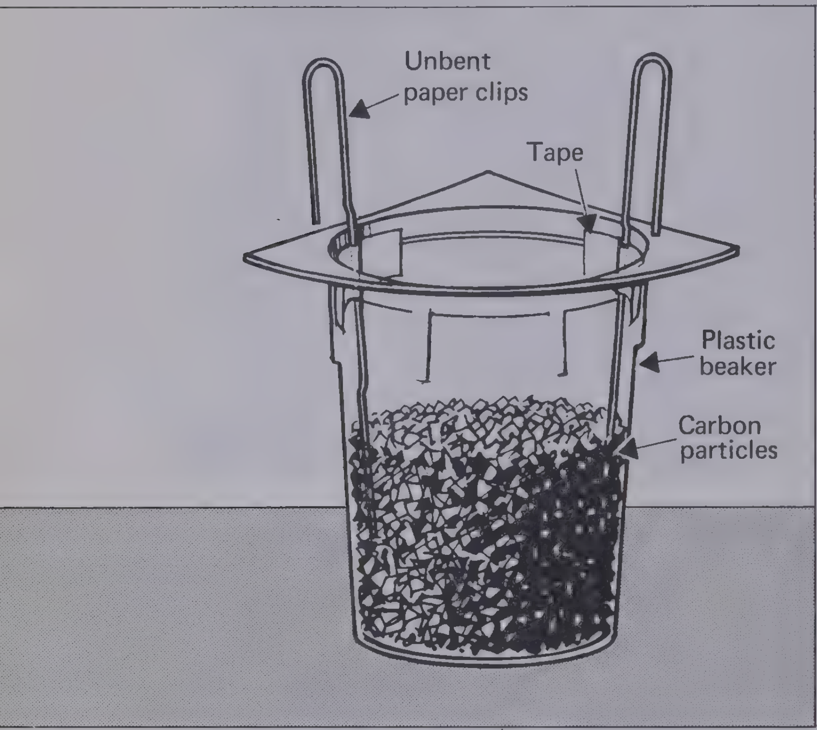
18. What happened to the amount of electricity as you went from four bulbs to one bulb?

19. As the number of bulbs increases, what happens to the amount of electricity?

All substances (for example, glass, carbon, copper) have something called *resistance.* In a series connection, when there is too much resistance, not enough current gets through for electrical gadgets to work right. When there is too little resistance, things may get too hot and burn up.

20. Does adding more bulbs increase or decrease the resistance in the circuit?

21. As the resistance increases, what does the current do?

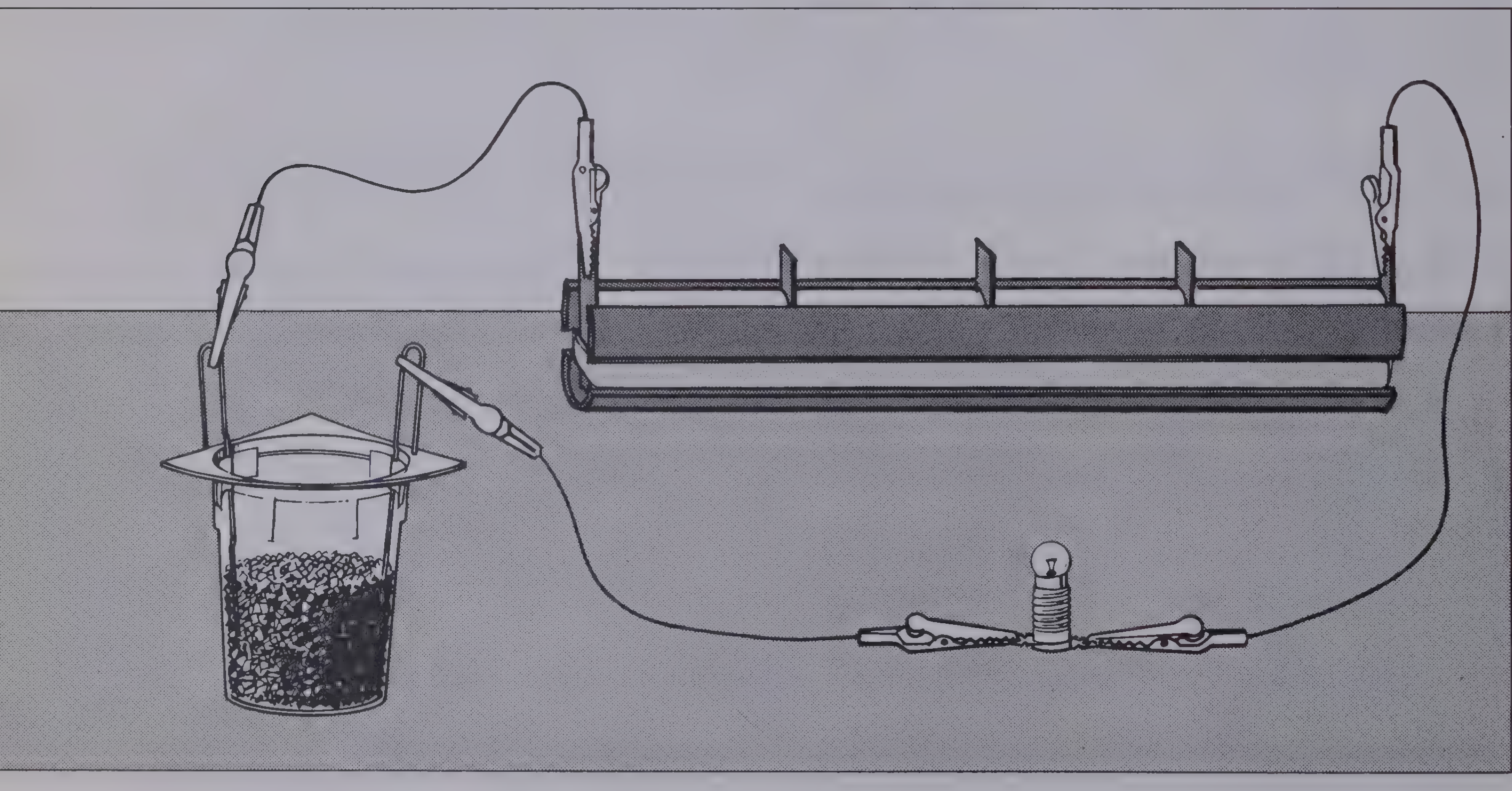


22. As resistance decreases, what does the current do?

C. SQUEEZE ME GENTLY

This investigation started with ideas about sound. Then it switched to resistance in electric circuits. The last step concerns the element *carbon* and how it carries electricity.

Unbend and clip 2 paper clips inside a 50 ml plastic beaker. Fill the beaker half full of carbon particles. Hook the tops of the paper clips to a battery pack, at four batteries, with one flashlight bulb in the circuit. Squeeze the beaker and watch the bulb.



23. What happens?

24. Stop squeezing. What happens?

25. How does the amount of electricity going through the bulb change when you press on the carbon particles?

26. How does the resistance of the carbon particles change when you press on them?

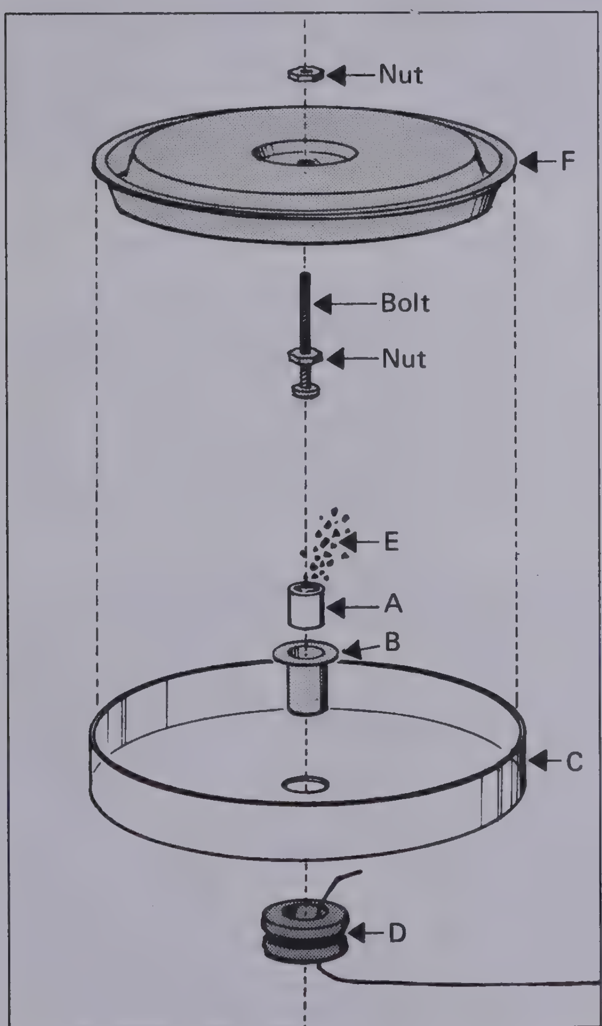
Try squeezing and letting go several times as fast as you can.

27. What happens?

28. What would happen if you could squeeze and let go 100 or 1000 times per second?

D. VIBRATE A COFFEE CUP LID?

You have just proved three things. First: vibrating objects produce sound. Second: resistance in an electric circuit controls the current. Third: pressure on carbon particles changes their resistance. We will use what we just learned to make an interesting gadget.

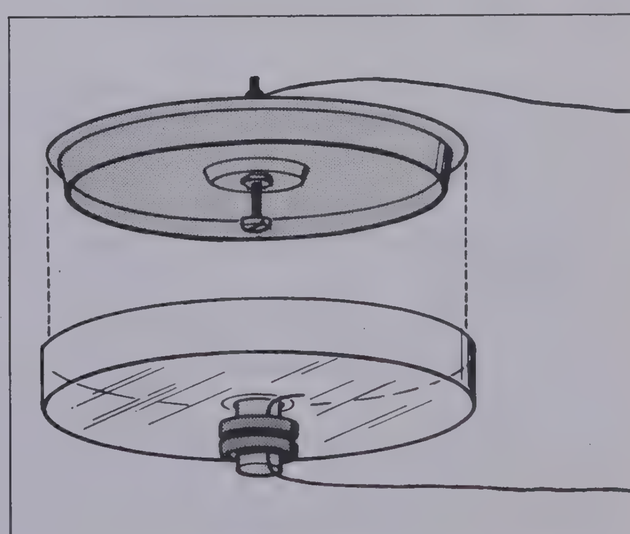


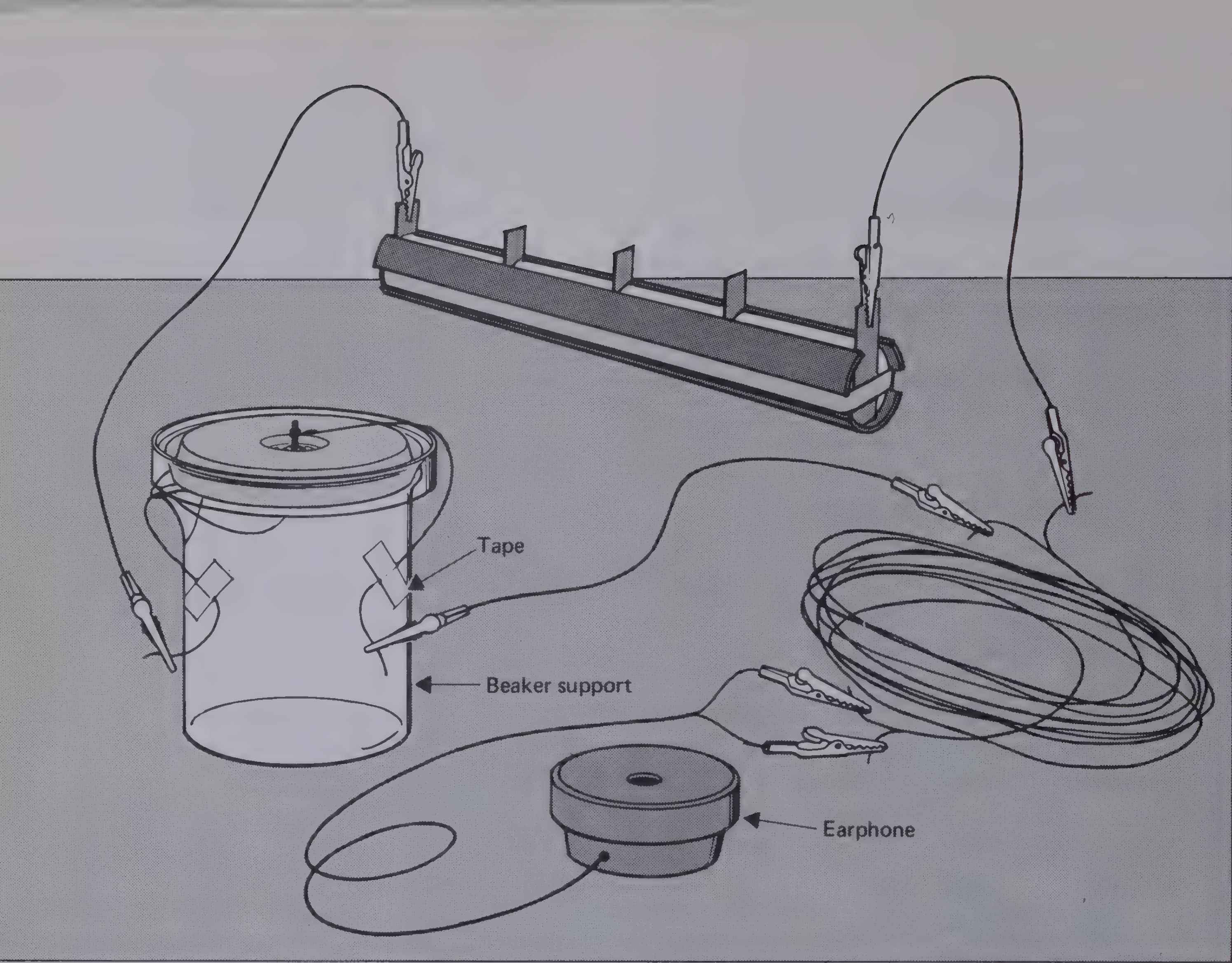
Sandpaper carefully the metal cap, B, inside and out, and the bolt on the lid, F.

Put the insulator, A, into the metal cap, B.

Push the metal cap, B, gently down through the hole in the bottom of the plastic dish, C.

Push the rubber washer, D, up over the end of the cap, B.





Slide one end of a connecting wire (without any alligator clips on it) under the rubber washer, D.

Half fill the insulator in cap B with carbon particles. Push any carbon particles that happened to fall on the edge of the insulator down into the insulator.

Twist a thin sandpapered wire, about 8" long, several times around the bolt on the plastic coffee cup lid.

Put the coffee cup lid into the plastic dish so that the head of the bolt goes into the insulator and rests on the carbon particles.

The plastic dish, C, should rest on something so that it sits level (on books, or on the top of a beaker).

Connect earphones and the coffee cup lid to four batteries as shown.

The electricity goes from one end of the battery through the wire to the top of the bolt.

29. It then passes down the bolt to what material?

After passing through the material you gave as your answer to the last question, it passes through the wire to the earphone.

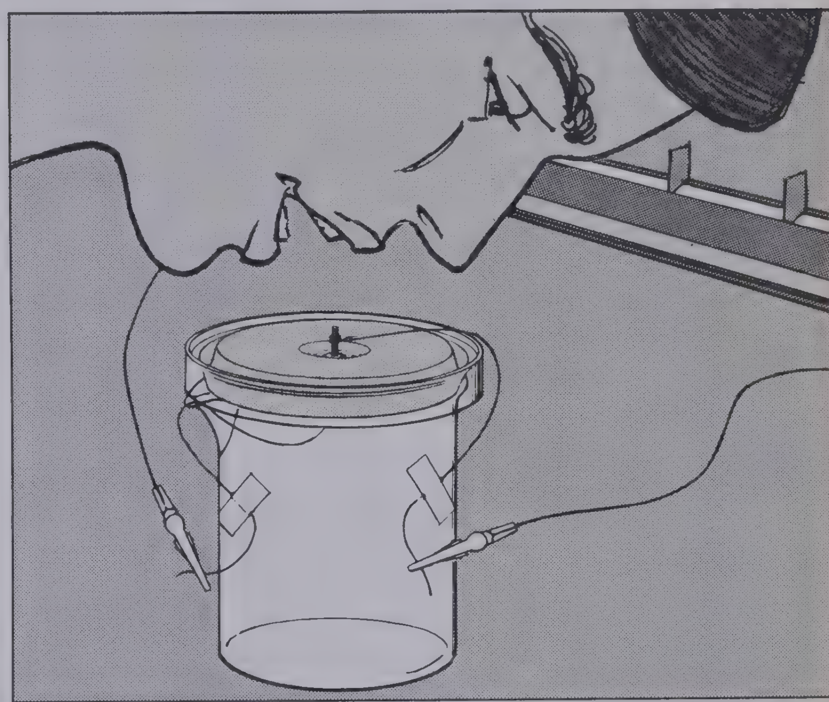
30. After passing through the earphone, it goes through a wire back to what?

31. What will happen to the amount of electricity passing around this circuit if you push down gently on the coffee cup lid? Explain.

32. What will happen when the current through the earphone changes?

33. Put the earphone to your ear and push down lightly on the coffee cup lid. What happens?

34. Blow directly down on the top of your coffee cup lid. Do you hear anything?



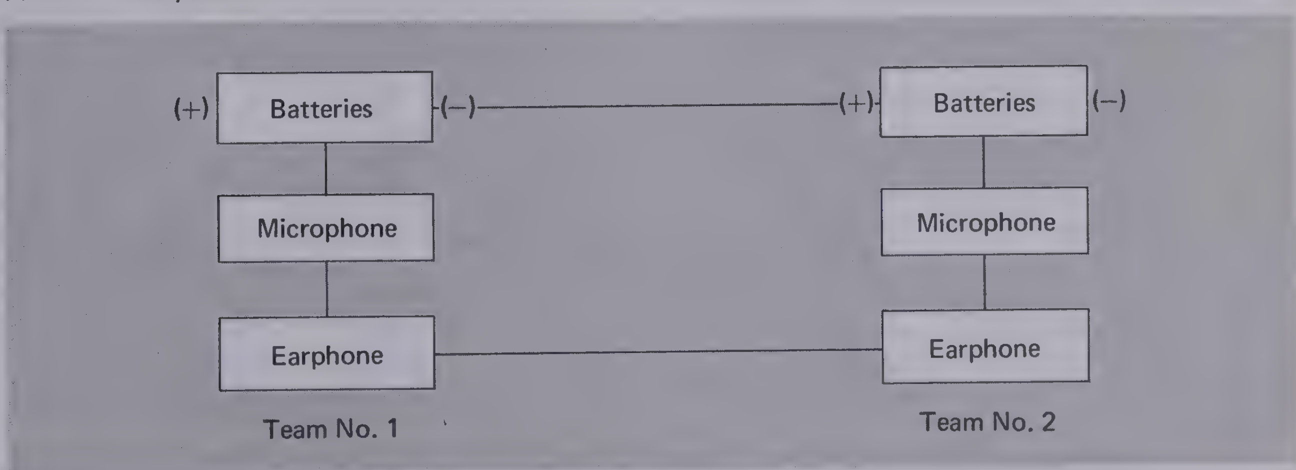
If you don't hear anything, try adding or taking away a few carbon particles and screwing the bolt up or down a little.

When blowing on the lid produces sound in the earphone, try this: have one team member take the earphone away from the microphone as far as the length of wire will allow. He should hold the earphone to his ear with one hand. With the other hand he should cover up his other ear.

The other team member should talk into the microphone from directly above it.

After you are able to get your microphone working well, team up with another group and make an intercom system. You may want to use more than four batteries for this.

An intercom system



E. DON'T CALL ME, I'LL CALL YOU

You started by vibrating the end of a ruler and finished with a communications system.

35. How far can you make the sound of your voice carry by shouting?

36. How far can you make it carry over a regular telephone?

37. What form does sound take in the telephone line?

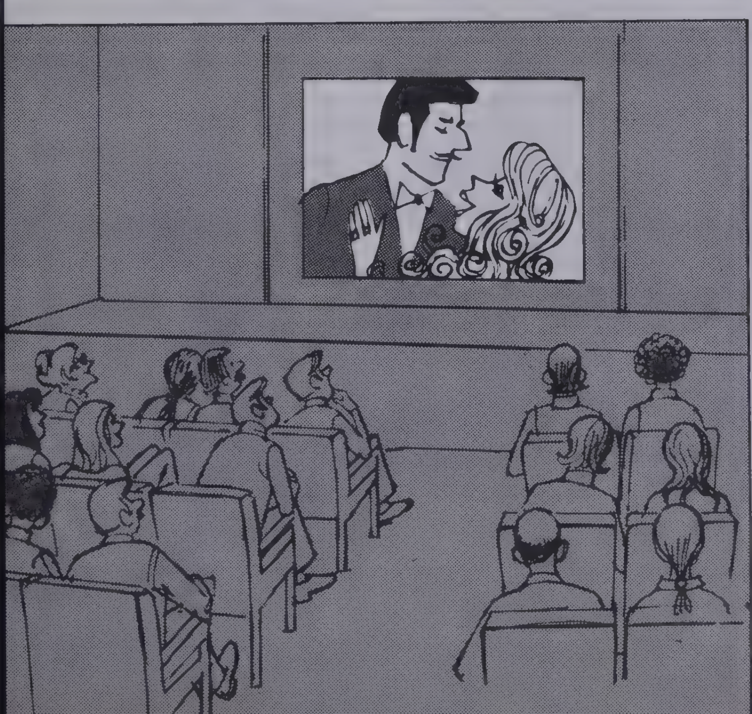
38. How does the microphone make the telephone possible?

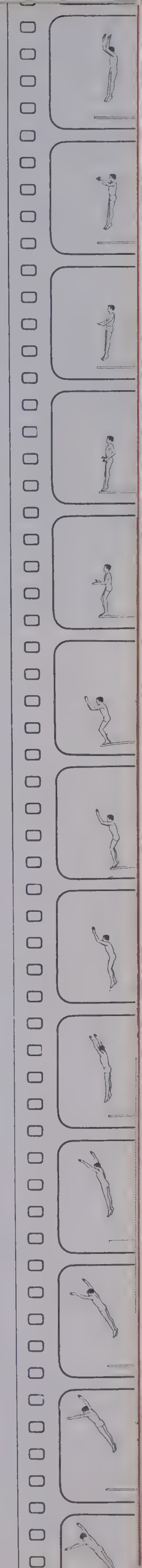
CONCEPT SUMMARY.

Investigation 10

It's Not for Real

Man has long been able to send messages over distances by using the interaction of matter and energy. In the past, the person receiving these messages usually had to decode them. You have seen how sounds are sent and received directly today, using modern electronics. But what about pictures? We know they are sent over long distances, too; but how?





A. BOXES, LITTLE BOXES

If someone told you the picture on the screen isn't really moving, would you believe him? You see motion in the picture on the TV screen and in the picture on the movie screen, don't you?

1. Look at the picture of a piece of movie film. What do you see?

2. Compare sections of the film. Choose two parts that are at opposite ends. Describe any differences you can see.

Each separate picture is called a *frame*. Look at the film frame by frame.

3. How much change can you see from one frame to the next?

4. Is something really moving on the screen? What do you think?

B. LET'S FLIP

What is really moving? How well do you trust your eyes? If you hold film up to the light and pull it past your eyes, all you will get is a blur. Let's try something else.

Warren Jorgensen from Bethel

Take your little book and flip through the pages quickly. Watch the drawings as you do so. Do it until you find the best flipping speed.

5. What seems to be happening?

6. What is really moving?

7. Why does it look as though the picture is moving?

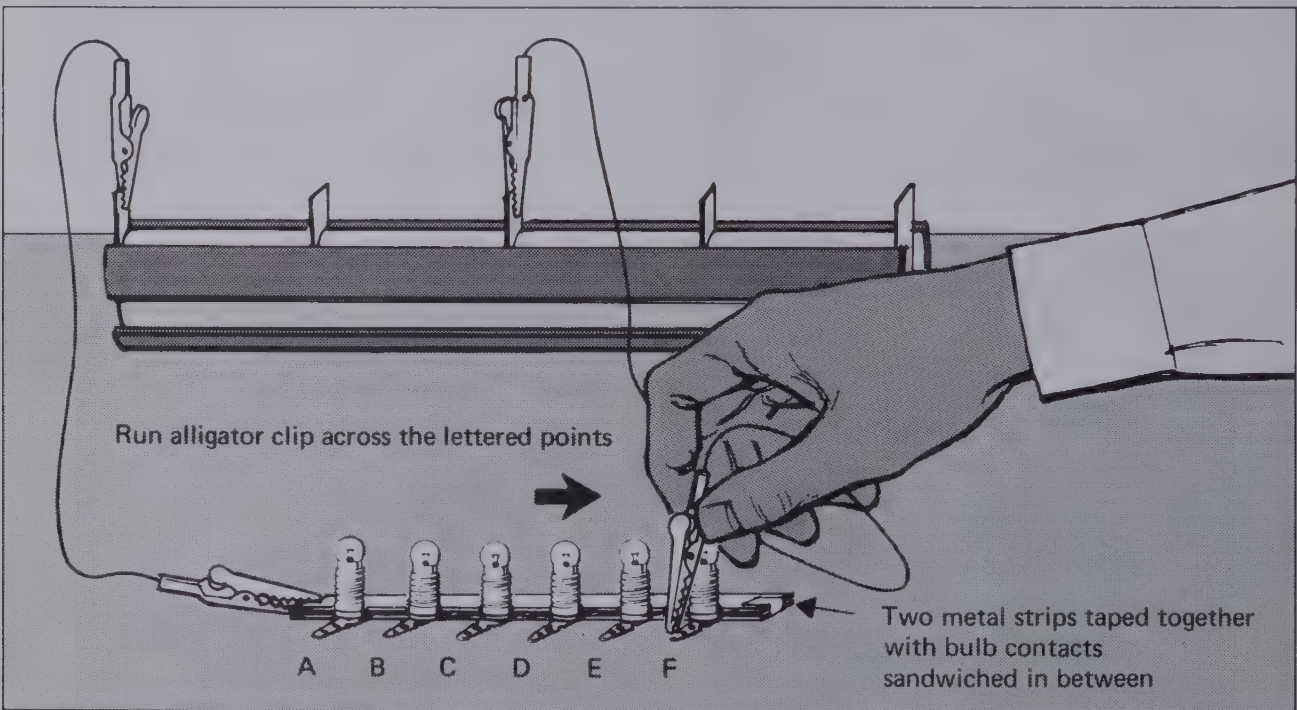
8. How does this apply to motion pictures?

9. How do you think it applies to television?

C. FOLLOW THE BLINKING BULB

The pictures seem to move, but do they? You see samples of this all the time. Think of a flashing sign over a theater or on a store front. The light seems to move along the sign. When you look closely, there is just a row of light bulbs.

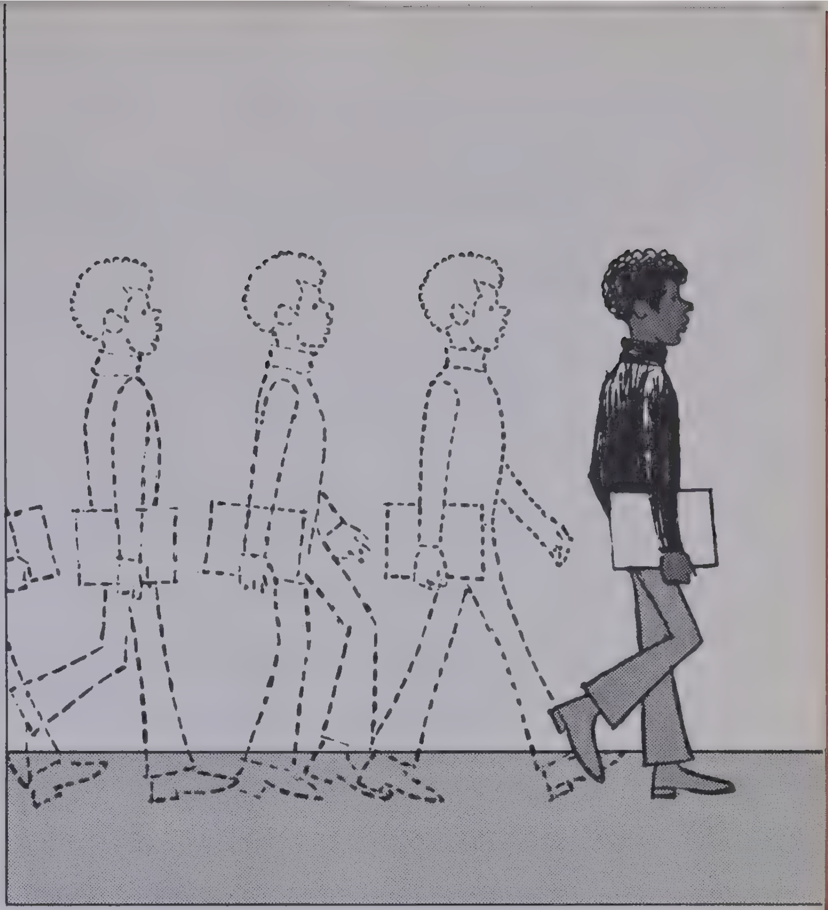
Connect four or more light bulbs to the battery pack in some way like that shown here. Wire them so that each light is independent of the rest. Arrange the lights close together in a row. They should be just one or two cm apart. Take the free lead from the battery pack and run it along the second contacts to the bulbs so that the bulbs flash on and off in turn. Start doing this slowly, then speed it up until all the lights go on and off in less than one second.



10. What does the light spot appear to do as you speed up?

11. How does this compare with the flip cards in part B?

12. What do flip cards and blinking lights seem to tell about the motion in movies and television?



D. I KEEP SEEING SPOTS

Things are not always what they seem. The pictures you thought were moving are turning out to be a fast series of stills. Your head does the rest. How are these still pictures formed?

13. Take a photograph clipped from a newspaper. Look at it from about 3 or 4 feet away. What do you see?

14. Bring the picture up close and look at it through a magnifying glass. What do you see?

15. What do you see when you come very close to the front of a TV screen?

16. How do you think TV pictures are formed?

E. IT'S ALL IN CODE

The newspaper picture is a group of black and white spots. The television picture is a bunch of light and dark spots. You can see the ink on a piece of paper, but how does TV do it?

Part of TV is like any radio system. There is a transmitter to produce magnetic waves and a receiver to pick them up. This takes care of the sound. The picture is more complicated. The light and dark signals are carried like loud and soft signals, but where do they go? It takes some tricky timing.

Look at the Picture Grid on your data sheet. Notice that each square lines up with a number at the top of the grid and a letter at the side.

17. How would you find square H17, for instance?

Using black and gray, fill in the grid as follows:

BLACK

C8, C9, C10, C11, C12, C13

D7, D8, D9, D10, D11, D12, D13, D14

E6, E7, E8, E9, E10, E11, E12, E13, E14, E15

F5, F6, F7, F8, F9, F10, F11, F12, F13, F14, F15

G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15

H4, H5, H6, H7, H15, H16

I4, I5, I6, I7, I9, I13, I15, I16

J4, J5, J7, J15, J16

K4, K5, K15, K16

L5, L15

M5, M6, M11, M12, M15

N6

R7, R8, R9, R10, R11, R12, R13

S7, S8, S9, S10, S11, S12, S13

T5, T6, T7, T8, T9, T10, T11, T12, T13, T14, T15, T16

GRAY

I11

J6, J11

K6, K7, K8, K11, K12

L6, L7, L8

M7, M8, M9

N7, N8, N9

O6, O7, O8, O9, O10

P7, P8, P9, P10, P11, P12

Q7, Q8, Q9, Q10

18. Could you recognize the picture by just looking at the numbered letters?

19. What is it a picture of?

20. Is the picture better from up close or back a few feet?

21. Is your TV picture at home clearer from up close or back a few feet?

22. What improvements would give a better message picture in the lab?

23. If this were TV, what do you think would change in the next picture?

F. IT'S ALL IN YOUR HEAD

This is how pictures are sent long distances. Close-up photographs of Mars and Venus are sent back from unmanned rockets in this way also. They are broken down into bits of information. Each bit is a light or a dark spot on the screen. Then, by careful timing in your TV, each light or dark spot is sent to just the right spot on the screen. It happens one picture at a time, 30 pictures a second. But making the light and dark spots move across the screen does not take place on your TV screen.

24. Where does it take place?

The ability to send picture information depends upon understanding many things. One is how light interacts with the eyes and the brain. The eyes and the brain are made of matter. Light is a form of energy.

25. What interaction are we back to again?

26. What understanding lets us send pictures through space?

CONCEPT SUMMARY.

Investigation 11

You Have to Stay Sharp

Whether it was hungry animals or poisonous plants, ancient man had to stay on his toes all the time. If he didn't look out for danger, he was killed.

Courtesy of the American Museum of Natural History

You don't go down the street watching out for tigers any more. Instead of hunting animals through the brush, you go to a supermarket. There you find man-made substances, as well as natural ones. You load up a shopping cart with cake mix, ammonia window cleaner, a sack of potatoes, detergent, ground beef, vegetables, frozen orange juice, chlorine bleach, nail polish, furniture polish in a spray can, bread, eggs, milk, and some TV dinners. Sounds harmless, but just be sure baby brother doesn't eat the detergent or drink the nail polish. Is the man-made environment really all that much safer than the natural one?

A. THE SHOPPING CART IS A GAS

Suppose the tiles around the bathroom shower become "super-dirty." The chlorine bleach doesn't get the mess off. Ammonia cleans glass, so why not use it? Maybe it and the bleach will work well together.

Put 15 ml of chlorine bleach in a small beaker. Add 15 ml of ammonia solution. Stir the solution with a glass rod. DON'T HOLD THE MIXTURE NEAR YOUR FACE. Use one hand to wave the vapor from over the beaker toward your face. Sniff carefully; don't take a deep drag.

1. What do you smell?

Turn on the water in the sink, then pour out the mixture. Rinse the beaker and let the water run for an extra couple of minutes. You may want to open some windows.

National Archives

You have just produced the poisonous gas *chlorine*. It killed thousands of soldiers in World War I. It is still killing people, including housewives who wanted to try a little harder.

2. What does this say about safety in our man-made environment?

B. FIRE AT YOUR FINGERTIPS?

It's almost time for dinner. Your nails are half done. There is a pot on the stove about to boil over. You reach out for it with fingers wet with nail polish. But wait a minute! Be careful!

Dip the end of a glass stirring rod into a bottle of nail polish. Pass the wet stirring rod through a flame.

3. What happens?

Pour some nail polish remover into a small evaporating dish. Test it with a flame.

4. How well does it burn?

5. What flammable liquids can you think of that occur out in nature, on the ground or in the ground?

6. Do you think it is dangerous to leave a bucket of gasoline in the kitchen? Explain.

Things can catch fire even when no flame of any kind is brought near them. All they have to do is get hot enough. Bringing flames near is only one way of getting them hot enough.

Some materials get hot enough to burn at much lower temperatures than do other materials. Take a small piece of wood. Hold a match to one corner for a few seconds.

U.S. Forest Service

7. What happens?

Put a small wad of absorbent cotton in an evaporating dish. Hold a match to one corner for a few seconds.

8. What happens?

9. Why use an asbestos pad under a clothes iron?

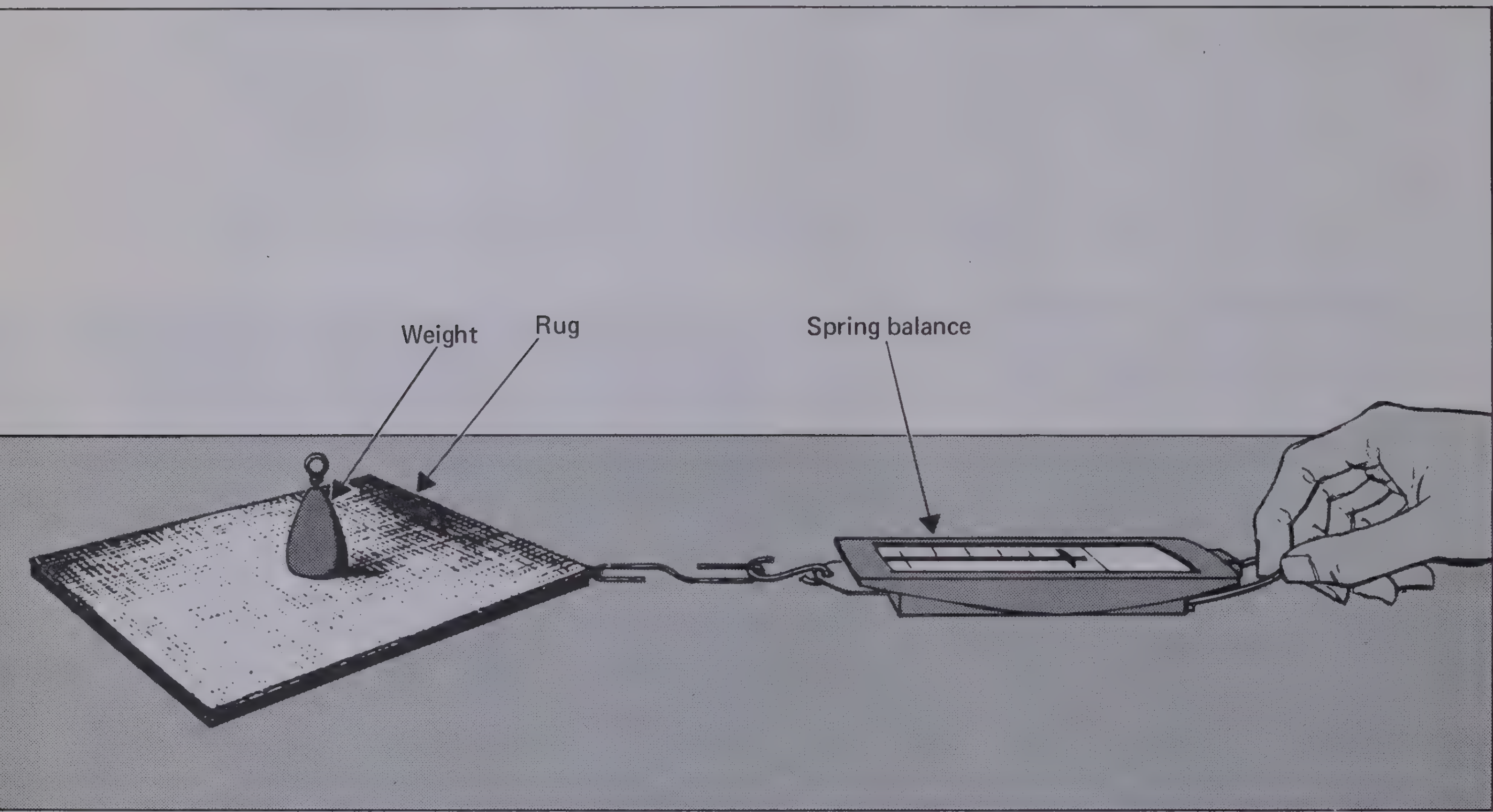
10. Fire is an interaction of matter and energy. How can knowing this help us to control our man-made environment?

C. DON'T SLIP AWAY FROM ME

The traps in our environment are not always as obvious as fire. You lean a ladder against the side of the house. When you are halfway up, the bottom begins to slide. Or maybe you come charging through the house and step on that little rug in the hall, and the rug doesn't stay there.

What decides when things slide and when they don't? If you know why oil is used in cars, you know part of the answer. But go back to the rug.

Your teacher has two pieces of rug of the same size. One has rubber backing, the other is plain. A paper-clip hook will be attached to the edge of each. A spring balance will be attached to the free end of the paper clip. First a weight will be placed on top of the unbacked rug, and the rug will be pulled slowly across the top of the desk by pulling on the spring balance.



11. What was the reading on the balance when the carpet began to slide?

Switch to the rubber-backed carpet. Pull it until it slips.

12. What was the reading on the balance?

13. How does the amount of force needed to slide the two kinds of carpet compare?

14. Which carpet is safer?

The force between the carpet and the table is *friction.* It appears whenever two surfaces touching each other move.

15. If you were designing automobile brakes, would you want to create high or low friction? Explain.

16. If you were designing ice skates, would you want to create high or low friction? Explain.

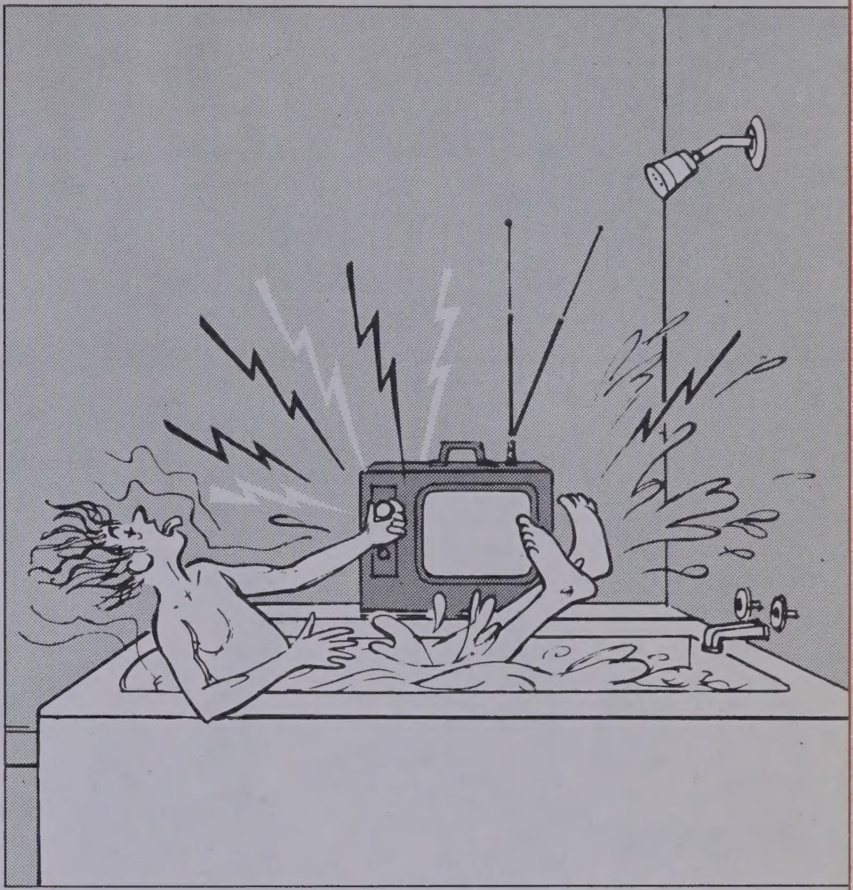
D. KEEPING ALIVE TAKES ENERGY

There are problems to staying in one piece in our man-made world. We have mentioned only a few. The different things you investigated were all interactions of some kind.

17. What interacts with matter to produce fire?

18. What kind of interaction produces slipping and sliding?

19. Learning to survive in our environment means learning to understand the interactions of two things. What are they?



Syd Greenberg from Photo Researchers

Warren Jorgensen from Bethel

20. Mention some other dangers you know about that are part of our man-made environment and are not in nature. Include things that you can buy in supermarkets and other stores. Mention things you have heard about that happened to your friends and neighbors.

CONCEPT SUMMARY.

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